

THE BOYS' LIFE OF THE WRIGHT BROTHERS

MITCHELL V. CHARNLEY



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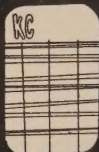
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The boys life of the
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THE BOYS' LIFE OF THE
WRIGHT BROTHERS

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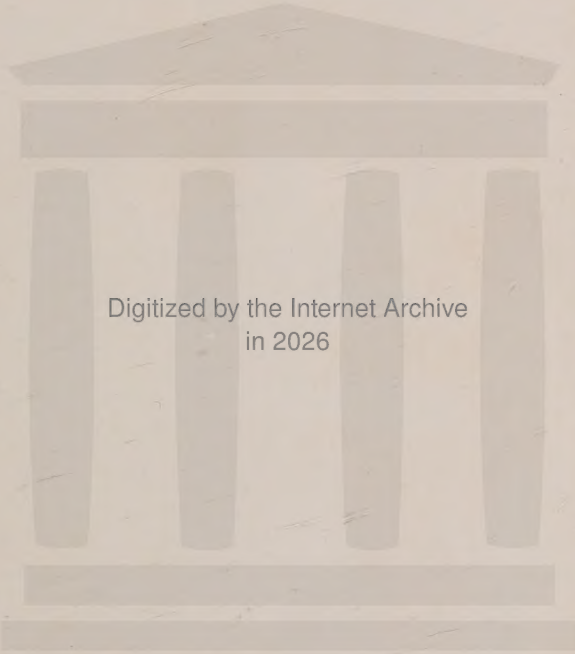
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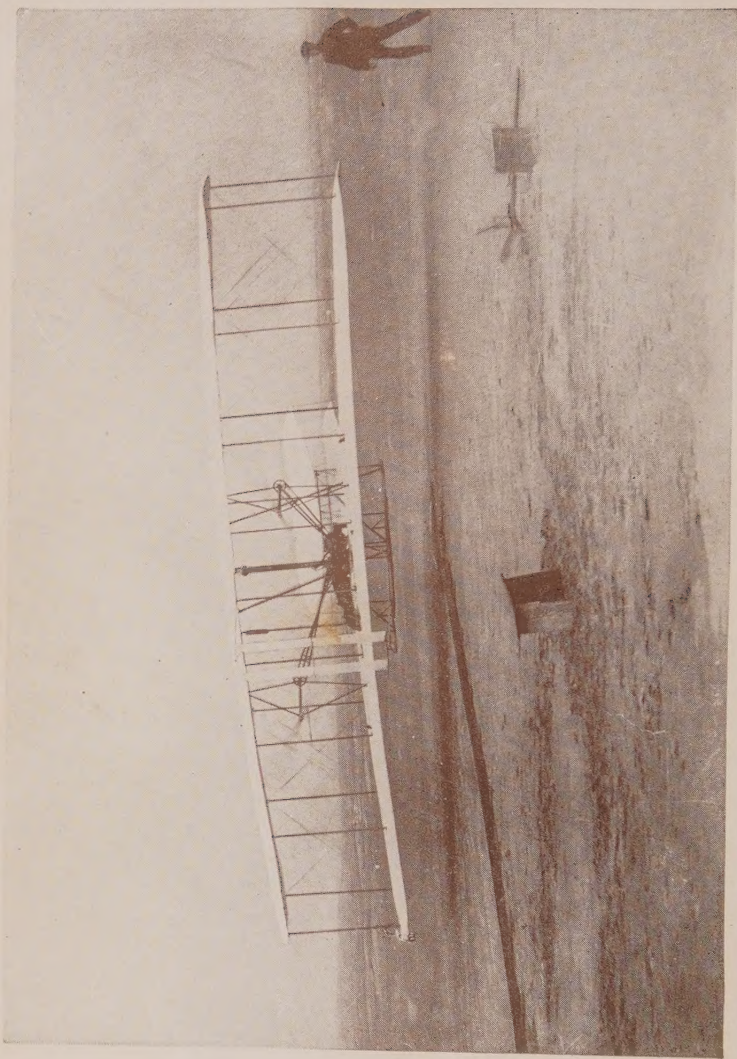
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LEAVING THE STARTING RAIL ON THE FIRST FLIGHT OF THE POWER MACHINE, KITTY HAWK, DECEMBER 17,
1903

THE BOYS' LIFE OF
The Wright Brothers

BY
MITCHELL V. CHARNLEY

ILLUSTRATED



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THE BOYS' LIFE
OF THE
WRIGHT BROTHERS

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MITCHELL V. CHARNLEY

January 27, 1928

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THE BOYS' LIFE OF THE
WRIGHT BROTHERS

THE BOYS' LIFE OF THE *WRIGHT BROTHERS*

CHAPTER I

THE TOY THAT FLEW

IT WAS a crisp autumn day in 1878—crisp enough so that the two younger Wright boys, Wilbur and Orville, were playing indoors in their Cedar Rapids, Iowa, home. The home and the town were still a little new to them, and they probably would have preferred to be outside exploring. There was lots about Cedar Rapids for boys of eleven and seven to find out, but there was plenty indoors, too. The Wright home, with its books and its workshop, always offered diversion.

So Wilbur and Orville were well occupied when the door from the street opened and their father, Bishop Milton Wright, entered. Bishop Wright had been “downtown,” and his hands concealed something he had bought. The boys saw a twinkle in his eyes, and they dropped what

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they were doing to watch. You never could tell what this sturdily-built, bearded father of theirs might plan to surprise them.

"Watch this, boys," commanded the man. "Don't let it get away!"

He opened his hands, and with a whir and a flash an odd-looking device leaped from them and headed straight for the ceiling. Even bumping the ceiling did not discourage it; it continued to spin its two curious wings and to bound and rebound. It seemed to be all white paper and shiny bamboo, a light, flimsy-looking apparatus.

"Look at the way it bats!" shouted Orville, the younger.

Wilbur was more scientific.

"What makes it stay up there?" he demanded.

By this time the little machine seemed to be losing energy; it was whirring less rapidly and settling slowly toward the floor. In a few seconds it was still, and the boys pounced on it avidly. They wanted to know all about it.

"It is called a *hélicoptère*, boys," Bishop Wright told them. "That's a French term ——"

"The way it whacks the ceiling, I think we ought to call it a 'bat,' " decided Orville. And so the flying toy was known thenceforth to the Wrights as the bat.

THE TOY THAT FLEW

It was a machine of cork, bamboo, and paper, they found, with two wings, or propellers, which whirled in opposite directions under power furnished by twisted rubber bands—exactly the kind of power boys of half a century later were to use for far more advanced model flying machines. Otherwise it was entirely different from anything air engineers of later years developed. For the building of heavier-than-air machines, in 1878, even as toys, was no science—it was only guess-work.

This did not reduce the fun Wil and Orv Wright derived from their little bat, however. A delicately made, easily destructible machine, it did not long survive the hard use to which they put it. They flew it indoors and out; they greeted “record flights” with shouts of enthusiasm, and frowned when it failed to perform as well as they thought it ought. . . . They would have gaped in polite amazement if anybody had suggested that, twenty-five years later, they might be feeling the same emotions about much the same kind of thing.

Wil and Orv played with the bat until there was no more bat left. They patched rents in the paper and repaired breaks in the bamboo. And the result was that by the time it became com-

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pletely unpatchable they knew as much about the toy as had the man who made it. They knew its dimensions, the details of its construction, and they knew its performance under varying conditions. This knowledge they packed away in the backs of their heads, not with the idea that they might use it later, but simply because it had already become their habit to study things and to remember them. A few years afterward they recalled all this knowledge of the bat and put it to practical use.

Thus Orville and Wilbur Wright, the boys who later were to give to the world the first successful machines that flew, had their first experience with practical aëronautics.

CHAPTER II

THE WRIGHT FAMILY

THE Wright family had been American almost as long as there had been civilization in America.

Genealogists have traced the Wright name back as far as John Wright, an Englishman living in the county of Essex in 1538. In 1636, only sixteen years after the Pilgrims came to the new land and built their first settlement at Plymouth, Samuel Wright settled as a farmer near what is now Springfield, Massachusetts. Samuel was, like most early New England Americans, a Puritan and a churchman of strictest tenets.

For more than a century his descendants remained in eastern America; many of them became prominent in the little Colonial settlements. Notable names among these were Edmond Freeman, the Reverend Joshua Moody, the Reverend John Russell, John Otis, and John Porter. Through more remote connections the Wrights were related to General Joseph Warren, hero at Bunker Hill; to General Ulysses S. Grant; and

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to President Grover Cleveland. Silas Wright, a governor of New York, died in New York State in 1847.

The family of the Wright boys' paternal grandmother had also long American residence behind it. First known in Holland in the fourteenth century, a branch settled on Long Island in 1650. Descendants of this branch went west, and the Van Cleve family became one of the leading pioneer groups of the Ohio Valley. In 1854 a descendant of it, Andrew H. Reeder, was governor of Kansas.

Milton Wright, father of Wilbur and Orville, was born in Rush County, Indiana, on November 17, 1828. He was given what was, for the pioneer Middle West, a good education; he went to Hartsville College in Indiana. There he became acquainted with a girl student, Susan Catherine Koerner, whose father was of German descent and who was born in Hillsborough, Virginia, on April 30, 1831. This girl had as keen an intellect as his own; she was the leading mathematician of her class, and she was interested not only in "book learning" but also in the little-known field of mechanics which held considerable attraction for young Milton Wright.

Perhaps it was his Puritan ancestry that de-

THE WRIGHT FAMILY

cided the young man to emulate so many of his forbears and become a minister. In 1850, when he was twenty-two years old, he was ordained as a pastor in the United Brethren Church. Nine years later, when he was thirty-one and Susan Koerner twenty-eight, they were married in Indiana.

There were not many congregations large enough to support a minister in Southern Indiana and Ohio in those days; consequently the young Reverend Mr. Wright spent much of his time traveling from one small church to another, holding services, conducting prayer meetings, officiating at marriages and funerals and baptisms, performing for dozens of communities the functions of spiritual leader. At one time he was president of the church council. After his days as a traveling minister were ended he continued to travel a good deal on inspection tours; it has been figured that, all in all, he covered some two hundred thousand miles.

Finally, in 1869, the Reverend Mr. Wright took his family to Dayton, Ohio, where he became editor of a church publication, the *Religious Telescope*. His family, by this time, included three sons—Reuchlin, Lorin, and Wilbur. Wilbur had been born in Henry County, Indiana,

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about eight miles from Newcastle, on April 16, 1867. Twins, born after Wilbur, did not live; Orville, the fourth son, was born in Dayton, August 19, 1871. Katharine, the only daughter, also was born in Dayton, exactly three years after Orville's birth.

The inventive and mechanical flair of the Wright family had commenced to show itself while Wilbur and Orville were still very young. Their father is said to have brought almost to perfection a typewriter of his own design and manufacture. He never patented it or attempted to sell it, however. Mrs. Wright herself proved to be extremely "handy with her hands" and continually helped her sons with toys and play-things they were making, or actually built things for them herself. At one time, it is related, she made a successful bob-sled for them. Some years later Lorin Wright invented, patented, and put on the market an improved form of hay press.

Mrs. Wright was a woman of broad cultural interests. She and her husband had collected a library of some two thousand volumes, and Mrs. Wright keenly encouraged her children to read widely. The result was that, while her family seemed to find its greatest collective interest in mechanical and technical affairs, it was never-

THE WRIGHT FAMILY

theless well grounded in literature, music, and art. It was Wilbur's habit of omnivorous reading that, twenty years later, aroused his dormant interest in aëronautics.

In 1877 the Reverend Mr. Wright's diligent services to his church were rewarded by his elevation to the rank of bishop. The next year his duties took him to Cedar Rapids, Iowa, and it was there that Wilbur and Orville made the acquaintance of the bat. The family remained in Cedar Rapids until 1881, then removed to Richmond, Indiana. Three years later came another move, this time back to Dayton.

Through all this change of residence and environment the Wright family became unusually closely knit. Wilbur and Orville, both reserved boys, rarely developed close outside friendships; rather they built up the strongest affection and loyalty for one another, and became companions who not only played and worked together, but almost thought together. Wilbur, of course, was several years ahead of Orville in school; he was perhaps the more studious boy of the two, a greater reader, with blue eyes that looked oddly pale under his thin brown hair, except on the rare occasions when he was keenly enthusiastic

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or vividly angry. Then they flashed and bit like blue diamonds in his swarthy face.

Orville was the enthusiast of the two. He was a little readier to make friends with others than Wilbur; he was much readier to attempt untried schemes. At the same time he was an experimenter like his brother, and always eager to work with Wil on some pet project. Orv's hair was dark brown, and his eyes blue. He was slim like Wilbur, but somewhat less strongly built.

Bishop and Mrs. Wright were not only parents, but also friends and advisers to the boys. If it were a giant kite they were making or merely a jack-knife they were sharpening, they were always sure of gaining help and advice from their father or their mother. Both were eager for their sons to develop their budding mechanical talents, and both aided them not only in finding the right things to read, but also in putting their ideas into being.

CHAPTER III

THE SECOND BAT

THE Wright family, like most late nineteenth-century families, was a closely knit group—a unit that did not often need to go outside itself for its amusements. As years went by, the two older boys, Reuchlin and Lorin, married and established their own homes; but this only increased the tendency of the five remaining in the household to hold together.

In Dayton the Wrights always lived on the West Side; their home was on Hawthorn Street. Orv had made friends with Ed Sines, a boy who lived down the block. Later this friendship was to develop into partnership. Ed always was one of the closest friends the Wright boys had. But this, like other relationships, was temporarily broken off in 1878.

There was no lack of things to do in the Cedar Rapids home. In the first place, school kept Wil and Orv occupied. Orv was hardly more than started, but Wil was well along. And there were supplements to school work, too, in the continual

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fire of new ideas, new reading, new enthusiasms Bishop and Mrs. Wright kept directed on their three children.

It was an age of fads, just as the twentieth century has been an age of fads. If there were not cross-word puzzles, there was wood-carving—the rage to make everything from the towel rack to the dining-room table in delicate engraving. If there were not radios for the boys to build, there was a turning lathe they had made themselves to operate.

But the Wrights—somewhat isolated by the mere fact that they were a minister's family, for even the friendliest of parishioners was inclined to hold the brood of so eminent an ecclesiastic as a bishop a little in awe—did not depend on outside fads to interest them. They have told how, at one time, their keenest interest was in Arctic exploration. Such men as the young Lieutenant Robert E. Peary were making stirringly courageous voyages into the unknown perils of the frigid North. Fridtjof Nansen was commencing his colorful sledge trips into uncharted parts of the world. And the Wrights read omnivorously about these explorations—books from available libraries, magazine articles, newspaper stories. The whole family was interested, and it is easy

THE SECOND BAT

to picture the evenings in their home, when all five listened eagerly to accounts of the explorers' adventures, or discussed with animation their chances and their perils and their importance.

The boys, about this time, had their own pet enthusiasm. It grew out of that *hélicoptère* their father had brought them. The original bat had not lasted long; but some time after it had gone beyond the possibility of repair they decided they wanted another.

"If somebody else could build that thing and make it fly, why couldn't we?" demanded Orv one day.

"I think we can!" replied Wil.

So they gathered fine strips of bamboo, sheets of heavy paper, bits of cork and light wood, and a pot of glue and went into their little workshop. They whittled and cut, measured and figured, built and discarded. They had to work from memory, for their original model had been completely wrecked by the hard usage to which they had put it. But they wrestled with the problems of lightness and strength and rubber-band power and balance, and at length they were ready to test out their first flying machine.

It flew!

It flew so successfully that, after their trials

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of the first model they built, they determined to make a larger one.

"We'll build it exactly to the same scale, but with bigger wings and stronger rubber bands," they decided. "It ought to fly twice as well."

Oddly, though, it refused to conform to this figuring. It went into the air, at least; but it did not come near to performing as well as had the smaller models, much less twice as well. They patiently went about the business of remaking it, lightening framework, improving wings, strengthening "power plant." The result was the same. They could discover no error in their construction—the larger machine seemed an exact replica, except in size, of the highly successful smaller ones.

But it wasn't as good a bat.

Still Wil and Orv weren't discouraged. They decided on a still larger machine—one that dwarfed the original tiny bat they had had. They labored over its parts with the diligence of beavers, and when at last it was completed and ready for a trial they felt sure of its flying qualities.

It wouldn't fly at all!

The boys were disheartened. As far as they could see, they had done everything exactly right.

THE SECOND BAT

Their father and mother could point out no fault in the little machine. It looked like the original bat grown up; its wings whirred and it even bounced a little when they wound up its rubber motor and released them. But it refused to get off the ground. The result was that, eventually, Wil and Orv came to the conclusion that building more machines that wouldn't work was mere waste of time. They commenced to turn their energies to ordinary kites—those, at least, they could build so that they'd fly marvelously.

It was years before the brothers learned the real cause of the failure of their increasingly large bats. For a machine of only twice the linear measurements of the small machine their father had brought home to them, eight times the power was required. The same proportions—double the measurements and cube the power—held for any larger machine. This law has caused much of the difficulty more modern aëronautical engineers have experienced in building helicopters, the airplanes designed to rise vertically from the ground. But young Wilbur and Orville Wright had no way of learning that back in Cedar Rapids or Richmond, Indiana, where they lived and worked and played from 1881 to 1884.

There were stories during some of those eve-

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nings the family had together. While Orv was very little Wil sometimes took it upon himself to entertain his younger brother, "making up" stories himself. Whatever the context of these stories, whether they started with a vague "once upon a time" of the more literal kind of subject better suited to Wilbur's practical mind, they always ended the same way.

"—— and then," Wil would conclude, while Orv was stifling his glee, "the boiler bust!"

That would be the signal for a loud outburst of mirth, for the "busting" of a boiler was not always the logical conclusion of Wilbur's stories.

There was music in the Wright home, and there was, of course, religion. Their belief in the power of their faith was something that did not leave the Wright boys.

CHAPTER IV

KITES—BASEBALL—SHINNY

BY THE time the Wrights returned to Dayton in 1884 Wilbur had completed three years of high school and Orville had a year of grammar school to finish before entering the Dayton High School. Wilbur was to go to Yale in the fall of 1885, and was diligently getting himself ready for it.

Going to college was not going to be easy. A clergyman is not often wealthy; Bishop Wright's salary never rose higher than \$1,500 a year, and at the time he was married he had had only \$200 a year. His wedding gift from his father had been \$1,000; Mrs. Wright had received a like amount from her father. The original \$2,000 and such savings as the minister and his wife had been able to make had been well invested, but the money to send a son to a big Eastern university was not readily to be found, even then. Anything Wilbur could lay by himself to help swell the college fund would have been welcome.

So Wil was not idle. He found small jobs to

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do, and did them well. His mother, in particular, had belief in his and Orv's ability and their future.

"Orville has powder under his heels," she told a neighbor once. "He's going to get along."

Meanwhile both Wil and Orv had plenty of play. Kite-flying had been one of their chief forms of recreation ever since the business of building bats had failed them; and although Wil was beginning to think himself a little old for such "kid's sport," both boys were skilled at it. Orv was known as an expert.

Their return to Dayton had meant renewal of their friendship with Ed Sines, the boy who lived down the block on Hawthorn Street. Somehow they had taken to calling Ed "James," and this was distorted into "Jammies"—a nickname none of the boys could explain a few years later, but one which always stuck. "Jammies" tells of their kite-flying.

"In those days there wasn't much on Dayton's West Side. The West Side is a comparatively low section of town, stretching out along the Miami River. When the river got high in the spring, it was often flooded—sometimes badly. The most important part of town was across the river.

"Parts of the West Side were built up, but

KITES—BASEBALL—SHINNY

other parts were little more than open fields, with occasional trees or fences. That made it fine for us with our kites. For successful kite-flying you have to have open country, in order to avoid being bothered by having the kites get tangled in chimneys or wires or branches.

"We used to go out there, day after day, and send our contrivances up. Just ordinary kites they were, mostly—we didn't bother ourselves much with trick affairs such as boys in later days sometimes built, for kite contests and so forth. We didn't even have contests—it seemed good enough to get the kite started up on a reasonably strong wind, then to lie in the shade of a tree and pay out string, or haul it in, as we choose.

"One game we played, Wil and Orv and I. We called it sending up messages. It was simple enough, too—we didn't take the trouble to figure out the aërial laws governing it. Or, anyway, I didn't—maybe Wil and Orv did, one time or another.

"The game was just this: We took small squares of colored paper, maybe four inches on a side, made holes in the centers of them and put the kite string through the holes. Then we gave them little shoves up into the air, and the wind caught them and carried them up along the strings

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straight to the kites. We used to get a lot of fun out of those little 'messages,' watching them shoot up the strings and seeing whose square of paper would reach the kite first."

By his own confession Ed was not always as successful at making kites as his friends.

"Once I built one," he says, "that wouldn't take the air at all. The only way I could make it stay off the ground was running with it. Wil and Orv thought that was mighty funny; their kites were pretty sure to fly! They called my kite Jammees' Runner and it was a long time before I heard the end of it.

"The kites we made were practically all of the conventional type—"kite-shaped," with frames of crossed sticks and a tail of little pieces of rags or paper. There was a bit of experimenting with box kites, but none of us carried this very far.

"And Wil and Orv didn't think for a minute, then, that years later they'd be trying to get another kind of machine to ride on air currents. All any of us knew was that, if a kite was well made, and there was enough wind, we could make it go up into the air the way we wanted it to."

That open country near the boys' home, known to them and to most of Dayton as "The Commons," served other purposes, too. It was there

KITES—BASEBALL—SHINNY

that Dayton boys met to play baseball, Ed Sines and the Wrights among them.

The game they played was of the "ole cat" variety. When a group met to start a game, the boy who first shouted "One!" was first batter; "Two!" was second, "Three!" catcher, and so on.

Baseball in the 'eighties was not of the variety twentieth-century boys came to know. Often a bat and a ball were the sole pieces of paraphernalia. Such luxuries as gloves and mitts and masks and catchers' chest protectors were rare when baseball was young; and the baseball was as hard as the big league balls of later years. Thus the game was, in some ways, more strenuous than the modified form it took in the days when costly apparatus was a necessary adjunct to every scrub contest.

Wil and Orv were no better and no worse at the game than most of their friends. They played often, and they enjoyed it. But it never became a ruling passion with them. They preferred working with tools—or making the tools themselves, as they were learning to do when the implement they needed was too expensive for their purses or not quite suited to their desires.

There was another game the boys played—Wil, the older, more than Orv. It was shinny, a kind

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of hockey on land. It was a game that called for a lot of running, hence endurance, and a lot of strength to wield the heavy shinny-stick with which the ball, or puck, was whaled toward the goal. It demanded, also, little science and much skill in evading a wildly swung stick. Bruises after a shinny game were plentiful.

One day during Wil's last year in high school he was struck a terrific blow in the mouth by a shinny-stick.

His upper lip was battered and bleeding when he reached home, and several teeth were damaged. But, worse than that, the blow had so shocked the eighteen-year-old youth's nervous system that, when the summer before he was to leave for New Haven and Yale came, he was in too poor health to consider it.

That change in Wilbur Wright's plans shaped his whole career. During the four years that followed he was forced to keep much to himself at home, conserving and building up tiny bit by tiny bit his shattered strength. With the help of his mother—herself an invalid, now, and facing the gradual wasting away which the disease they called "consumption" always meant in those days—he attempted to make up at home for the opportunities he lost by not going to college. He read

KITES—BASEBALL—SHINNY

interminably ; he studied a hundred subjects. He experimented as much as his health would let him. He developed a mechanical skill and a nicety of habit, whether it were in empirical theory or in actual handling a file or chisel or lathe, that were invaluable to him later.

And at the same time Wil found an almost feminine gentleness in his hands when it came to caring for his mother. Perhaps it was that he, too, was invalid—that his sympathy translated itself in terms of his loving attention. At any rate, Wil was nurse and comforter for his mother during the four years he spent at home—the years he should have been at college, and the last years of Mrs. Wright's life.

She died July 4, 1889.

CHAPTER V

SINES AND WRIGHT, PRINTERS

WHEN Wilbur became unable to work and play with his young brother as he had always done, Orville turned more than ever to the companionship of the boy down the block, Jammee Sines.

It was about the time that Orv entered high school that he became interested in printing. Jammee had a toy set of rubber type and an inking pad, and Orv, from his skill at wood-carving, evolved the idea that this had commercial possibilities. A Dayton coal firm had a trade mark showing several grinning negroes' heads with a verse beneath them, and Orv ingeniously substituted donkeys' heads for the originals. Then, with Jammee's type, he labored for a week to make it print the four-line stanza that accompanied the heads. But the assortment of letters was not big enough—he couldn't make it.

Finally Bishop Wright, believing Orv's perseverance deserved notice, bought him a twenty-five pound font of type. This started the two

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boys in the printing business, and for weeks they experimented and managed to keep their two homes more or less in an uproar with their type and ink and paper. They found they needed more equipment.

"Without a press, we can't do much business," Orv declared.

"And where can we get a press?" pondered Jammees.

"That's easy," Orv replied. "We'll make it."

He got a heavy roller, probably from some dismantled mill, for a starter. He found an old gravestone—exactly what he needed for the perfectly smooth bed of such a press! He rigged up a device of two-by-fours and levers that, with the aid of a man at each end of the stone, sent the roller back and forth over the type. For each impression the type had to be hand-inked with a brayer. But when the machine was completed it produced several hundred impressions an hour—a record considerably faster than that of the Washington hand press in general use at the time.

Business was not exactly rushing in the first days of the Sines and Wright partnership. The first job brought in a total of two dollars—this after all the money the boys could scrape together

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had gone for equipment. That two dollars precipitated an argument. Jammees considered it profit, and thought each of them ought to get half of it. Orv, looking about him at the lack of proper tools and materials, wanted to put it back into the business. And it was a question that was not easy to settle. But at last it was settled, and the business kept going.

It produced only "job work" at first—hand-bills, cards, tickets, dodgers. Probably it produced a good deal of experimental matter, too, for the boys had a good deal to learn about the art of printing. Slowly they learned, however, and they began to cast about for greater fields to conquer.

While Orville was still only fifteen years old, he and Jammees decided on the production of a newspaper. It was to be called *The Midget*, to consist of four pages of three columns each and to contain neighborhood news and special articles of special interest to boys. The partners had the complete approval and assistance of Bishop Wright, who had been a full-fledged editor himself ten years before, in their project.

"It's a fine idea—if you do a fine job with it," he told them.

So they set a publication date, announced it to

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all of their friends, and went to work. It turned out that the capacity of those four three-column forms was simply miraculous. The boys had allowed themselves what seemed ample time to gather the news, set it up laboriously by hand—machine-set type was hardly known in those days, and such a device as the linotype would have been far beyond even Orville's ingenious mind—and print the four pages. The day of publication arrived and they had only enough material to fill pages one, two, and four.

"We *could* put off publication for a couple of days and get some more news," suggested Jammees, doubtfully. "But I don't think that would be——"

"Not so good," agreed Orv. "Tell you what—we can't issue it with a blank sheet, and we can't delay it. Let's just make page three an advertisement for the firm!"

So that was selected as the makeshift solution. A beautiful big script type was selected, and across the three blank columns was emblazoned:

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Then the first copy of *The Midget* was taken by two rather sheepish boys to Bishop Wright for inspection.

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His answer was not long in coming. He perused the front and back pages approvingly enough, then opened the little sheet. His eyes fell on the "advertisement" and he stared.

"What's this?"

Orv explained, and the Bishop's stern face did not relax. "What do you think about it, Orville?" he asked.

"Well, it might be better," Orville admitted. "We didn't want to have our first issue late, though. . . ."

"It seems to me," decided the Bishop, "that it would be better not to publish at all if you don't publish properly. It's a poor job, boys. What do you think?"

That was the end of *The Midget*. The first issue was never circulated, and future issues were postponed indefinitely. Incidentally, Orv learned a lesson there that he used often in after years—the lesson that he should not try to do a thing until he was ready to do it properly in every detail. That rule helped immeasurably in making Wright airplanes fly.

The job-printing firm of Sines and Wright continued, even though *The Midget* expired. Gradually Orv and Jammes built up a small business, and eventually they moved their shop into a small

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storeroom. Orv was at work on a new press—a larger, more efficient machine, more on the scheme of the big presses the large printing houses were using. The type still lay on a flat bed, but the bed moved under the roller. The paper, fed into the press from the high “table,” revolved around the roller, passed over the type and was deposited at the side.

The machine was by no means a model in appearance. Observers declare that everything from light string to adhesive tape and pieces of rope were used in repairing it. But, like the other press, it worked.

And it was unusual enough to interest the head of a printers’ supply house, who visited the shop periodically on selling trips. For a long time this man never happened to come to the shop when the press was actually operating, and he complained that he didn’t believe the thing would really run. The boys could not be persuaded to start it simply for an exhibition—it was too strenuous a job.

But finally, one day some time later, he happened in when the press was in full blast. His interest was unbounded. He watched it from all sides; he peered down at it from above; and be-

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fore he was through the owners found him on his back on the floor, head far underneath.

"You've got me beat," he said when he emerged. "I don't know why it works. But work it certainly does—and well, too!"

CHAPTER VI

A NEW PARTNERSHIP

BY THE time the press was operating satisfactorily a change had taken place in the firm.

By 1889 Wil had almost completely regained his strength. College he had given up and he was eager to get to work. So he asked for a share in the printing business.

The business had developed to a point, now, where there was ready place for a third man. There was need for capital, too. And, thanks to Bishop Wright's confidence in his sons, they had some capital. At his wife's death, the Bishop had decided to divide half of his property among his children—four sons and a daughter. He had turned the little house in Dayton, valued at about \$3,000, over to Katharine—not that she was ready to use it then, for she was hardly old enough to enter Oberlin College, as she planned to do. He had sold, for \$10,500, a farm in Iowa and divided the proceeds equally among Reuchlin,

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Lorin, Wilbur, and Orville. He retained in his own name a farm in Indiana.

Thus Wil and Orv had a small sum of money for investment in the printing company, if they should need it. (As it developed, they did not touch this sum until years later.) It was finally decided that they should take it over—that Jammees Sines should remain with them, but as employee instead of partner. A new venture, the *West Side News*, was projected—a weekly newspaper. Wilbur was to do the major portion of the editorial work; Orv was to be mechanical chief; Jammees was to be general handy man, printer's devil and reporter, type-setter and advertisement solicitor. As it worked out, the realms of the three overlapped widely. Each of the young men found himself doing every kind of duty.

The new project wrote *finis* to Orville's schooling. Up to that time he had continued with his high-school work, doing his printing-shop tasks in the afternoons, evenings, and Saturdays. Now he left school entirely to devote all his time to the Wright brothers' partnership.

And this meant that neither of the men who were to be responsible for one of the most deeply scientific of modern achievements was to have a

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scientific college education. Health had prevented Wil from attending Yale; now business kept Orv at home.

But Thomas Edison had not had half so much schooling as the Wright boys. Benjamin Franklin had been a poverty-stricken youth forced to starve in order to study. Over in Michigan at that very time a young machinist was working who had had the skimpiest of educations, but who was to become the marvel of the mechanical age—Henry Ford.

As compared with these and thousands of other boys, then, the Wrights had a training by no means slim. The fact that they had obtained it within the walls of their own home rather than in the classic environment of a tradition-bound campus made it none the less efficacious. They had broad backgrounds of practical and cultural knowledge; they knew how to read and what to read; they knew also where to look for the kind of information they wanted. Lack of college training did not mean to Wil and Orv what it meant to most of their friends.

In February, 1889, the *West Side News* made its appearance. It was a four-column, four-page paper. It was to appear on Saturdays—and its first issue had no blank pages!

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The *West Side News* was a mild success. In three months it was enlarged, and Wil was designated officially its editor, with Orv as publisher. It "came out" every Saturday evening, and as late as ten o'clock Wil, Orv, and Jammees set out, those Saturdays, to deliver it to its four hundred subscribers.

The combined efforts of Orv and Jammees even sufficed to sell a limited amount of advertising space in the paper. Eventually, the two came to have regular "customers." For they found that often Mr. Sines could sell space to a grocer or a furniture dealer or a roof-mender whom Mr. Wright could not even interest, and that Mr. Wright was just as effective with a bicycle merchant or an insurance man who refused to listen to Mr. Sines!

Meanwhile the job-printing end of the business kept up satisfactorily, and Wil and Orv were slowly putting aside a little money. They were becoming interested, too, in the sport that was sweeping the country—bicycle riding and racing. As their interest in this developed, it was to change their business completely. While the *West Side News* was in operation, however, bicycling was hardly more than an avocation.

During their publishing days the Wright

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brothers attempted two other major ventures. One was a daily newspaper, the *Evening Item*, brought out in April, 1890. The *Item* was too elaborate an experiment for Dayton's West Side, they soon discovered. They operated it for only a few weeks; then, when it showed only in red on their books, they gave it up.

The other venture was a weekly magazine, *Snapshots*. It made its first appearance several years later, in the autumn of 1894. Its chief feature was the series of articles written by Wil, its editor. These articles were concerned with local affairs, and in style and attitude gave evidence of the "incisive and often sarcastic manner in which he was able to express himself throughout life. He was a fearless critic, and he wrote about Dayton practices and politics with a vigorous but always kindly pen that was unusually forceful in the municipal life of the growing city."

Snapshots, like the *West Side News*, made money. Its size and circulation increased slowly. But the Wrights were finding another interest—a rapidly kindling interest in bicycle repair and manufacture.

In 1893 Wil and Orv had opened a small bicycle shop directly across the street from their

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printing office. For three years they operated both businesses, still with Ed Sines as a helper. Finally, in 1896, the new business entirely superseded the old, and they gave up printing and publishing altogether.

CHAPTER VII

BICYCLE-BUILDING

BICYCLE-RIDING was a nation-wide craze in the 'nineties. Everybody bicycled—everybody from five-year-old children to staid old matrons and white-bearded grandfathers. One of the most popular diversions was earning membership in the "Century Club"—a club of those who had made hundred-mile trips on their bicycles.

Bloomer girls made their appearance and shocked the nation. Wonderful plaid riding-breeches for men became popular. And it was the ambition of every boy to have his own "wheel" and perhaps to enter some of the hundreds of races which sporting clubs, county fairs, rival cities or manufacturers were perennially promoting.

But it was not easy to own a bicycle. They were expensive. In the days when the "new-fangled" machines with comparatively small wheels and somewhat lighter frames became popular, it was not uncommon to pay \$150 or

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\$175 for a good bicycle. The occasional "tandem" or two-seated machine, and of course the less frequent three- and four-seater, was far more costly.

Wil and Orv Wright evaded this difficulty in the manner long since familiar to them. They built their own tandem. They obtained two old-fashioned high bicycle wheels, of the type seen only in museums today; they got hold of chains, sprockets, pedals, and seats. And then they connected the two wheels together with fifteen feet of gas pipe.

"It'll shock the natives when we take it out!" snickered Orv, surveying the finished product in the privacy of their workshop.

It did. The Wright tandem became, for a few weeks, one of the sights of Dayton. The two boys rode everywhere on it, and Daytonians in time became accustomed to the two-wheeled monster. In time, too, the brothers tired of it, and turned to more ordinary but more useful machines.

Both of the boys—now young men of twenty-six and twenty-two, but still known in Dayton, as they always were, as the Wright boys—were hardy riders. Wil was long and lean and enduring. He had completely recovered from the

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nervous shock that blow from a shinny-club had given him; his muscles were hard and his nerve steady. He was not, however, a sprinter. Road riding was his specialty—riding requiring tenacity and phlegmatic courage.

Orv, on the contrary, went in for shorter races. His character differed from Wilbur's in its quick enthusiasm contrasted with the other's slower steadiness, his frankness and eagerness contrasted with Wilbur's more judicious ability to make haste slowly. Their riding had the same differences.

Racing in those days was often a perilous business. Ostensibly a good deal of the riding was on an amateur basis. But actually, with the interests of bicycle manufacturers in having their machines come out at the head of the list, there was considerable under-cover payment of successful riders. As soon as an "amateur" had established a reputation by winning a few races, bicycle-makers were after him to ride their particular machines. Often they offered to build a racing model to his own specifications, to furnish him with riding togs, pay his expenses, give him what then seemed like a big "salary." There were prizes in the races, too, so that many young

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men were making good livings in "amateur racing."

The result of this was that the races became markedly bitter. Ordinarily they were of fairly short distances—one to five miles—on dirt tracks. Teams sometimes entered races; often riders entered as individuals. The individual, particularly if he were known as a dangerous man, frequently found himself in a bad way, for it was an easy maneuver for two members of an opposing team to "pocket" him near the start, hold him behind or between them throughout the race, and allow other members of their team to pull away and come in far ahead.

In cases of this kind it took not only hard, fast riding, but also keen strategy and bold courage to get away from the pocket riders. Spills were frequent, for many riders risked collisions rather than allow themselves to be held back, or a rival to get past.

And it was in this kind of riding that Orv Wright became best known. He was daring in getting out of pockets and courageous in the bad tumbles he was often unable to avoid. He won occasional prizes, but he never considered himself a highly successful rider, in spite of his minor victories.

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Years later, when he was known throughout the world for his scientific achievements, he was going to Washington from Dayton with Peter W. Klinger, another Dayton business man who had been, in the 'eighties and 'nineties, a conspicuously successful bicycle racer. The talk turned to those long-past racing days as the train thundered along.

"You'll never know," said Orville Wright, "how I used to envy you and some of the other fellows back in those years."

Klinger was astounded. "Envy! Me? What for?"

"If you'd eaten as much dust as I did, you'd know!" responded Orv with a grin.

Had Orv been able to devote all his time to bicycle-racing, he might not have trailed so often. But the affairs of the Wright Cycle Company, as the brothers named their new venture, were too pressing. The business started in 1893 as a simple bicycle-repair shop—a shop for which there was increasing patronage, for the Wrights soon found themselves with a reputation for doing things well. And they did everything, from the easiest puncture repair to the most compound kind of surgery on mangled frames.

The idea that they might manufacture bicycles

themselves seems simply to have evolved. Neither Wil nor Orv, later, would claim credit for suggesting it. That, however, was always the case. The two brothers worked together perfectly; their ideas supplemented one another. Not that they always agreed, at first, on a new suggestion. They argued frequently and heatedly and lengthily. But their arguments were not often bitter, and they always resulted, in the end, in a satisfactory solution of the problem they had been studying, with a more comprehensive answer to it than either one, by himself, would likely have given.

At any rate, they commenced not only to repair but also to build bicycles. Their interest in racing dwindled slowly, and their interest in their business grew.

Before long the "Van Cleve" machine—named after Catherine Van Cleve, one of the Wright ancestors who had been a very early settler in Dayton, landing there on the shore of the Miami on April 1st of the year the city was founded, 1796—was gaining considerable local repute for excellence of construction and durability. Its builders had added to it several features of their own invention, notably a new kind of brake.

They also built a cheaper machine. It was not

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long before the growth of the bicycle business forbade them to give time to the printing shop across the street, and in 1896 it was given up entirely.

As in the printing shop, the work had, to a certain extent, divided itself up. Jammes Sines again was general handy man. Filing, smoothing, fitting, assembly fell to his lot. Orv, as the business developed, came to handle the enameling, an important branch of the work of manufacturing fine bicycles. Wil, with the sureness of hand and eye he had cultivated, took care of the brazing—the delicate business of joining firmly and neatly the various pieces of tubing which made up the machine's frame.

The brazer was another triumph of Wright handicraft. There was a good brazer on the market at the time, but it had two drawbacks: it was not precisely fitted to the work they wanted to do, and it was expensive. So Wil and Orv simply went about the business of making their own brazer—a somewhat involved apparatus, best understood by the layman by its likeness to the similar, but far more simple, soldering iron or machine for joining bits of softer metal.

Their brazer worked, as did all of the tools they made. And this included nearly every implement

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with which the Wrights worked. They made everything from files and wrenches to intricate lathes; and not always because they were cheaper.

"Sometimes we like to make our own tools because we *know* they'll be all right," explained one of the brothers one day. "We make them properly, and we can put perfect confidence in them after they're made. That's important."

Bicycles weren't the only things they repaired. Once a broken stop-watch lay on their workbench. A hand had come off, and watchsmiths in Dayton unanimously agreed that the nature of the break made repair impossible. Wil and Orv didn't think so.

"Tire cement will hold lots more things than tires and rims together," they decided. "Let's try it."

They did. It worked perfectly.

Bicycle-racing, by the time the manufacturing was well established, was pretty well a thing of the past. But one day Wil, Orv, and Jammees got to discussing Jammees' possibilities as a racer, and it was decided that a match race between him and Henry Ruse, a young friend of them all, would be a good test.

Jammees was not so sure. He had no confidence in his racing proclivities. At length he

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agreed, however, and on the chosen day he and young Ruse, together with Wil and Orv, went to the race track. The race was to be for one mile.

"No science to that race!" Jammee's chuckled in later years. "I think it was probably a record-breaker—the slowest mile ever ridden in competition. First Henry was ahead, then I was—we see-sawed back and forth like the hands of a man climbing a rope. We must have changed lead half a dozen times while we struggled around that track.

"To this day I don't know how it happened. But it seemed to be my turn to be ahead when we crossed the finish line. I don't remember much about it, because I tumbled off my wheel and lay there where I fell until I got some of my breath back.

"And when I was able to look around, I saw Wil and Orv in just about as bad shape as I was—only they were gasping with laughter, not exercise! Orv was leaning up against a fence and nearly splitting, and Wil was about as far gone.

"Anyway, I said then that that was my last bicycle race—and I've kept my word!"

CHAPTER VIII

THE AIRPLANE IDEA

IN SPITE of the quantity of work he managed to accomplish every day at the plant of the Wright Cycle Company, Wilbur did not give up the reading habit he had formed during his childhood and intensified in those days when he had had to stay home so much of the time. He read everything—newspapers, magazines, pamphlets, books. He was particularly interested in scientific and mechanical books, and the home library was particularly well stocked with volumes of this kind. Wil was soon to have use for much of the scientific knowledge he had packed into his head.

For, one day in 1896, he read a dispatch in the local newspapers announcing the accidental death of a German, Otto Lilienthal. This man, it seemed, had been experimenting for five years with man-carrying kites. He had actually made them bear him through the air, from a higher to a lower level. He had worked out a lot of theories which might or might not be sound.

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And finally, while he was making a "flight," his big kite had stalled eighteen yards above the ground and Lilienthal had fallen with it to his death.

Wil showed that small dispatch to Orv.

"Makes me think of all the kite-flying we used to do," he said. "Didn't think, then, that a kite would carry a man."

"This kite didn't," replied Orv, soberly. "But some that Lilienthal built did, all right. I wonder whether there's really anything in it."

The keen blue eyes in Wil's thin face were beginning to sparkle, and Orv's were already aglow. They looked at each other an instant.

"Let's find out!" they said together.

Thanks to his hours of reading, Wilbur Wright knew just how to go about finding out.

"First," he told his brother, "we must learn all we can about flight—about what it is that keeps things in the air. If we *know*, we can avoid what happened to Lilienthal. And if we don't, if we try to work by guess, chances are mighty small of getting half as far as he did."

That was the principle guiding every aërial experiment Wil and Orv Wright ever made. They believed in chancing *nothing*. First get all the information available on the subject; comb it

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through, discard what isn't usable; work out theories on paper or in miniature experiment; then, provided every condition is satisfactory, make trials.

A long-winded, sometimes nerve-wracking method, that—one demanding mountains of patience, but one that seemed exactly suited to Wil's temperament, and to Orv's as the younger brother grew older.

Wil's first move was to go to the shelves of the family library and take down a volume he had already read several times—Professor Marey's *Animal Mechanism*. He wanted to read about birds. Birds, he reasoned, were better flyers than men could ever be, and if he could learn even a few of their secrets he would have a start.

That was the beginning. For months, then, the boys devoted spare hours to the study of feathered flight—even stole daylight hours to lie under trees out on the Commons and watch flocks of crows, lone hawks, darting swallows, great circling buzzards.

"The person who merely watches the flight of a bird gains the impression that the bird has nothing to think of but the flapping of its wings," Wil wrote several years later concerning these

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observations. "As a matter of fact, this is a very small part of its mental labor. Even to mention all the things the bird must constantly keep in mind in order to fly securely would take a big book.

"If I take a piece of paper, hold it parallel with the ground and let it fall quickly, it will not settle steadily down as a staid, sensible piece of paper ought to do, but insists on contravening every recognized rule of decorum, turning over and darting hither and thither in the most erratic manner, much after the style of an untrained horse. Yet this is the style of steed that men must learn to manage before flying can become an everyday sport.

"The bird has learned this art of equilibrium, and learned it so thoroughly that its skill is not apparent to our sight."

Nevertheless, the boys' enthusiasm and determination to find out about the "art of equilibrium" was only whetted by their study of birds.

"Say! but that'll be sport, to be able to ride around on currents of air that way," said Orv enviously one day as they were watching a hawk's lazy soaring.

And it was in that spirit that they continued their investigations. They had no notion that

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sometime human flight might become anything more than a sport. It was like bicycling—something that ought to be exhilarating, that would stir the blood and excite the imagination. But a commercial possibility—a means of attaining almost superhuman speed and traveling incredible distances—above all, a military weapon?

Not to Wil and Orv Wright. To them it was just a game.

An absorbing game, however. They read more and more—they sought more up-to-date books than their home library afforded. And they continued to watch birds in flight.

"It's a funny thing," chuckled a friend once, "to see those two boys, working away on a bicycle in their shop, suddenly dash to the window when they hear a whir of wings. More than once I've seen them do just that, though, to watch a few sparrows or sometimes a high flight of ducks.

"And it's funnier to see them sit down, afterward, forgetting all about the wheel they'd been putting together, and argue about just what it was that those birds did to fly such-and-such a way!"

Their reading got them to thinking not only about the problem of remaining in the air, but also about how to get there—about what

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aëronauts later learned to call the "take-off." One of the best descriptions they found of what a bird—particularly a big, heavy bird—does in starting a flight from the ground was that written by a member of the old Aëronautical Society of Great Britain, a man who had observed the method of the eagle:

"An approach to within eighty yards arouses the king of birds from his apathy. He partly opens his wings, but stirs not yet from his station. On gaining a few feet more, he begins to walk away with half-expanded but motionless wings. Now for the chance. Fire! A charge of No. 3 from eleven-bore rattled audibly but ineffectively upon his densely feathered body; his walk increases to a run; he gathers speed with his slowly waving wings, and eventually leaves the ground. Rising at a gradual inclination, he mounts aloft and sails majestically away to his place of refuge in the Libyan range, distant at least five miles from where he rose.

"Some fragments of feathers denoted the spot where the shot had struck him. The marks of his claws were traceable in the sandy soil as at first, with firm and decided digs, he forced his way; but as he lightened his body and increased his speed with the aid of his wings, the imprints of

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his talons gradually merged into long scratches. The measured distance from the point where these vanished to the place where he had stood proved that, with all the stimulus that the shot must have given to his exertions, he had been compelled to run fully twenty yards before he could raise himself from the earth."

Wil and Orv studied air currents, too. On lazy warm Sunday afternoons when they lay in fields to watch birds they gradually learned to notice every visible quirk of the wind. They saw miniature whirlwinds sweeping across ploughed acres, raising funnels of gray-brown dust with them; they noted the crazy performances of pieces of paper caught by vagrant breezes and twisted and twirled and turned. They observed the manner in which air currents seemed to follow hill slopes, and particularly the manner in which birds made use of such currents.

"A bird is really an airplane," Orv said later, describing the result of those hours of reading and watching. "The portions of its wings near the body are used as planes of support, while the more flexible parts outside, when flapped, act as propellers. Some of the soaring birds are little more than animated sailing machines, and few can rise without a running start.

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"Everyone who has been outdoors has seen a buzzard or a hawk soaring; and everyone at sea has seen gulls sailing after a steamship for miles with scarcely a movement of the wings. All these birds are doing the same thing—they are balancing on rising currents of air. The buzzards and hawks find the currents blowing upward off the land; gulls that follow steamers from New York to Florida are merely sliding downhill a thousand miles on rising currents in the wake of the steamer, and on hot air rising from her smokestacks.

"On clear, warm days buzzards find the high, rotary rising currents of air and go sailing round and round in them. On damp, windy days they hang above the edge of a steep hill on the air which comes rising up its slope. From their position in the air they can glide downhill at will."

Thus Wil and Orv came to understand the manner in which these living flying machines made use of air currents, even though they had not solved the problem of the construction of a bird's "planes" or wings. This, of course, they had no desire to do. They had read, among other things, the tale of Dædalus and Icarus, his son—the legend that was probably based on some

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early experimenters' attempts to emulate bird flight. Dædalus, says the myth, made great wings of wax-joined feathers, and flew with them attached bird-fashion to his arms. But Icarus soared too near the sun, and the heat of its rays melted the wax and plunged Icarus to his death in the ocean at the foot of a cliff.

The Wright brothers knew that feathered wings were not the solution of their problem. And they had to seek farther than the flight of birds to find it.

CHAPTER IX

PIONEERS OF FLIGHT

THE Wright brothers learned, through all their observations, that observations meant little. They knew, now, that birds had special secrets of equilibrium; what the secrets might be they had hardly an inkling. They knew that air currents are not steady, dependable, smooth-riding streams like a placid creek, but tricky, erratic, quickly-changing forces varying direction and power, often, every few feet. Every slope, every clump of trees or bushes, every house, they learned, sends up its slanting wave; and currents move not in straight, orderly procession, but in whirling rotary masses often reaching hundreds of feet into the air.

"Why, when there's a strong wind, the air near the ground is more treacherous than the water in the Niagara Gorge," exclaimed Orv one day.

"True," returned Wil, laconically. "And that means that we've got to know more than how the *wind* behaves. We've got to know how a man-

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bearing kite will behave in such a wind. And the only way to learn that is to try it!"

Later he expressed his conclusions in different words, but to the same effect:

"There are two ways of learning to ride a fractious horse: one is to get on him and learn by actual practice how each motion and trick may best be met; the other is to sit on the fence and watch the beast awhile, and then retire to the house and at leisure figure out the best way of overcoming his jumps and kicks.

"This latter system is the safest; but the former, on the whole, turns out the larger proportion of good riders!

"It is very much the same in learning to ride a flying-machine. If you are looking for perfect safety you will do well to sit on a fence and watch the birds; but if you really wish to learn you must mount a machine and become acquainted with its tricks by actual trial."

Nevertheless, Wil and Orv felt themselves far from advanced enough in their knowledge to attempt to take a glider into the air. The accident to Lilienthal had served as a caution to the growing number of men experimenting with artificial flight. The Wrights, by nature inclined to be

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very sure of what they were doing before they attempted it, became doubly careful.

And so, as their eagerness to commence experiments increased, they dived into everything they could find between book covers on the subject of aviation.

The century just closing had been one of unparalleled interest in human flight. As early as 1809 Sir George Cayley, an eminent British scientist, speaking before the Institute of Civil Engineers in London, described plans for a flying-machine powered by an internal-combustion engine. Sir George did not actually construct his machine; aëronautical engineers later declared that, if he had, following closely his original plans, his machine would probably have flown. In 1842 other scientists did follow his plans; but they substituted a steam engine for the power plant Sir George had suggested, and the engine was too heavy to allow the machine to take the air.

The man generally called "America's first aëronaut" was Charles F. Durant, a young New York scientist born in 1805. Even in the early nineteenth century ballooning, the form of aviation chosen by Durant, was not new. The previous century had seen occasional ascensions by

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lighter-than-air craft in Europe. But in the New World the sport was unknown.

Durant was an energetic young man interested in various branches of science; he is, today, better known for his writings than for his contribution to aëronautical knowledge. When he was twenty-three years old he decided he needed to know a great deal about air currents, and he went to France forthwith to study ballooning. He returned two years later and proceeded to make his first ascent at New York in 1830.

Durant was showman as well as aëronaut. Before each flight he distributed humorously doleful "farewell poems" to the huge crowds that always gathered to watch him. He advertised his plans well in advance, and always managed to keep himself well in the center of the spotlight.

All in all, Durant made twelve ascensions. One of them ended uncomfortably—but not disastrously—in Boston Harbor; this, of course, was excellent advertising for the young aëronaut. He went as high as twenty thousand feet above the surface of the earth, and learned a number of theretofore unknown facts about air currents, air temperatures, and so forth.

From 1885 to the final years of the century aërial experiment and activity doubled and

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tripled. Public interest throughout the world was keen, and "there was high hope that the age of flying was at hand." Not only in America, but also in France, Germany, England, and other countries were there being made important attempts at solving the age-old problem.

Otto Lilienthal, the man whose death had aroused the Wrights' dormant interest in the subject, started aëronautical experiments in 1871. Lilienthal was a Berlin engineer. He went about attacking his problem, it seems, in much the same manner as the Wrights did. For it was not until 1891, twenty years later, that he began making actual flights.

Lilienthal attempted to emulate bird flight far more closely than did most other experimenters. The glider he finally worked out was an odd-looking arrangement of bird-like wings and tail which he strapped to his body "on line with his shoulders"—that is, the big wings, with a total spread of some 151 square feet, were attached at his shoulders so that his arms could, to a certain extent, manipulate them. They were not to be flapped; their construction of osier framework and calico covering was rigid. But Lilienthal's theory of flight called for shifting his body with

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respect to the wings in order to help maintain their balance in the air.

Rather than make his glides from a hillside, as other experimenters were doing, Lilienthal had a tower built; from this he launched himself, sometimes from a height of a hundred feet, boldly into the wind. When it is considered that, in five years, he spent no more than five hours in the air, his success does not seem great. He made one glide of three hundred meters—almost a thousand feet. But ordinarily he remained in the air only an extremely short time—a matter of seconds. And finally, in 1896, his machine refused to glide. It stalled in the air, lost its supporting balance, and crashed to earth, killing its pilot.

Nevertheless, Wilbur and Orville Wright considered Lilienthal's work remarkably good.

"The wonder was not that he had done so little," wrote Wil, "but that he had done so much. It would not be considered at all safe for a bicycle-rider to attempt to ride through a crowded city street after only five hours' practice, spread out in bits of ten seconds each over a period of five years; yet Lilienthal, with his brief practice, was remarkably successful in meeting the fluctuations and eddies of wind gusts.

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“We thought that if some method of practising by the hour instead of by the second could be found, there would be hope of advancing the solution of a very difficult problem.”

So they read Lilienthal's writings and studied his tables of air pressure with greatest diligence. They speculated on his plans for power flight—he had been working toward the installation of a motor in his glider at the time of his death. And they devoured information about other experimenters.

Chief among these was Octave Chanute, a Frenchman who had been living in Chicago as a civil engineer. They read his *Progress in Flying Machines*, and they studied the records of the more than seven hundred successful glides he had made, without accident, in the 'eighties. They were impressed by the various types of gliders he had built, and by his declaration, made only a month before Lilienthal fell to his death, that the German's glider was unsafe. They wrote to him for help in answering some of the questions they were beginning to put into words, and they received courteous help. In later years, when they were making their own experiments, this same Octave Chanute was to be one of their strongest aids and encouragements.

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They also read such books as Mouillard's *Empire of the Air*, Samuel Pierpont Langley's *Experiments in Aërodynamics*, pamphlets on aëronautics published by the Smithsonian Institution, and the *Aëronautical Annals* for 1895, 1896, and 1897. They learned of the new theory of superposed planes—two surfaces, one above the other—proposed by the Englishman Wenham and developed by Chanute and another scientist, Stringfellow.

And they read, on October 2, 1899, of the death in England of Percy S. Pilcher. Pilcher had been, like Lilienthal, one of the most successful gliders in history. He had followed the so-called "kite style" of flying. Placing himself in his giant kite, he had hired small boys to pull it at the end of a rope until it rose on the wind to float for a few seconds itself; later he had used a team of horses in the same manner. Then, on September 30, 1899, he had fallen. The next day he died. Like Lilienthal, he had been making plans for a power-driven machine when he suffered his fatal accident.

CHAPTER X

HOW ABOUT POWER FLIGHT?

ALL of these men were disciples of the "school of soaring flight," as the Wrights termed it. Lilienthal, Pilcher, Mouillard, and the rest had data on natural flight—gliding—and from them Wil and Orv took most of their points of departure. But there was another school, represented by such men as Sir Hiram Maxim of England, Langley of Washington, and M. Ader of France—the school of power flight.

Each of these men, by this time, had built power flying machines of promise. The Maxim machine was the first.

By 1894 Sir Hiram had spent more than \$100,000 in his extensive experiments. He had succeeded in building a gigantic biplane with a propeller of at least twelve feet in diameter, an upper wing twenty feet in the air, and a total weight approaching four tons. The machine had a big steam-driven motor, and Sir Hiram's plan was to test it while it was held to the ground by the circular track on which it ran. This was in-

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side the shed where it was built—he did not attempt to take it out-of-doors.

Early tests showed that Sir Hiram had builded better than he knew. The huge motor generated a pull of 10,000 pounds, and the machine's performance indicated that it had a good chance of flying. But it came to grief during a trial one day. Its power was too great for the track; it ripped loose, and its operators did not know how to balance or steer it. It was badly damaged, and Sir Hiram was discouraged. He gave up his experiments.

In France, at about the same time, M. Ader was working under the auspices of the French government on a machine that was reported to have attained a certain success. No authoritative figures were given out by the promoters of the work; it was understood that the machine was steam-driven, with two propellers and a fifty-four-foot wing spread. Ader claimed for his invention a height in flight of sixty feet and a distance of nearly a thousand. But in every flight, according to stories of it, the machine was wrecked!

Professor Langley, working under the auspices of the Smithsonian Institution, flew a model plane successfully in the same year—1896. His ma-

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chine was a biplane (one wing behind, rather than above, the other) with fifteen feet of wing spread, two steam-driven propellers, and a total weight of twenty-eight pounds. His experiments were very secretive; but it was announced that the small plane made trial flights of a mile in one and three-quarters minutes.

Thus, before the Wright brothers made their first attempt at gliding, there had been approaches to successful power flight by non-man-carrying planes. Of these the Wrights knew—they studied what little data was available about them as they did the volumes of information on soaring flight. They had to decide between the two. And their decision was that they chose to work with soaring flight.

There were two reasons for this. One was the cost of power flight; the other was that Wil and Orv had nothing more than sport in mind in their researches, and soaring flight seemed to them to offer the larger possibilities.

Besides, they were influenced, they declared later, "by the extraordinary charm and enthusiasm with which the apostles of soaring flight set forth the beauties of sailing through air on fixed wings, deriving motive power from the wind itself."

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And "at the time we were extremely impatient at the wasteful extravagance of mounting delicate and costly machinery on wings which no one knew how to manage!"

For, during all this study of birds and air currents and pioneering in flight, the brothers were continuing their mildly prosperous bicycle business. They were still far from wealthy; the time was to come when they had spent every cent they had in the advancement of the very costly machinery set in unmanageable wings they now scorned.

It was in the evenings at home that they did most of their studying at this time. Bishop Wright, become white-bearded but none the less hale, and their sister Katharine, home from Oberlin and a teacher of Latin in the Steele High School, made up the family circle. And father and sister were almost as deeply interested in the fascinating new craze the boys had got as were the boys themselves. They listened to violent discussions eagerly, sometimes joined in themselves; they occasionally brought home, for Wil and Orv to dig through, new books or pamphlets or ideas. And once in a while, so tradition says, they begged for peace.

"Just for one evening—can't we talk about

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something else than Lilienthal and laws of air pressure?"

It is easy to imagine the little Wright family on one of those evenings. Bishop Wright, stalwart, short white beard forming a picturesque frame for his square face; Katharine, perhaps preparing Latin lessons for her next day's classes, in the long full skirts and balloon-sleeved, high-necked shirtwaists the period made fashionable; Wilbur's increasing baldness accentuating the length and slimness of his face, his blue eyes puzzling over some aërial formula; Orville with short black mustache, following Wil's figures or scribbling some of his own.

Probably there was a gas reading-lamp hissing in the center of the room, and a gas grate fire humming at one side—for Dayton is in the natural-gas district and gas was both cheap (the more costly electricity was just coming into vogue then) and plentiful. There were newspapers and books on the center table, and bookshelves on the wall. There was no tobacco smoke—the Wrights did not use cigars or cigarettes. And there was sure to be a Bible somewhere in evidence.

The picture was not always the same, of course. Some evenings the brothers were not home—they were trying out ideas in miniature in

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their workshop. Other interruptions arose from time to time. But much of the thinking and figuring and scheming that in time brought flight into the realm of everyday accomplishment was done in those evenings in the little frame house in Dayton.

CHAPTER XI

"THE PROBLEM WE MUST SOLVE"

GALILEO, the Italian astronomer, was imprisoned in Rome for daring to believe that stars were anything but angel-hung lamps. Robert Fulton was nearly laughed off Manhattan Island because he made so ridiculous a statement as this: "Some day a steam-propelled ship will cross the Atlantic Ocean."

In the late nineteenth century such visionary experimenters as Chanute, Langley, Maxim, Ader, and the Wrights were pityingly lumped into the class of the "inventors" of perpetual motion.

Of "Darius Green and his flying machine" the poet John Townsend Trowbridge had jested gayly, pointing out that nothing could have been quite so outlandish as young Darius's attempts to launch himself off his father's barn roof with actual hope of flying.

Moreover, many leading experimenters in aëronautics were giving up their work. Chanute, after a biplane built by one of his assistants, A.

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M. Hering, in 1897, and equipped with a gasoline motor, had failed, temporarily ceased his labors. Maxim had stopped with the expenditure of \$100,000; Ader had stopped. Professor Langley apparently had halted, although it became known later that he had been granted \$50,000 by the United States government and was continuing his work.

For the Wrights the question of expense was growing bigger. Wil and Orv had none of the governmental financial and moral encouragement that kept Langley, Ader, and others going. They had no private support, and their own resources were very limited.

But never for an instant did they consider dropping the problem they had tackled. For to them it was a game. They had no hope of making money from flying; they had high hopes of extracting from it a tremendous lot of fun, both in solving a never-before-solved difficulty and in actually gliding safely and swiftly, at their own will, through the air.

Those conditions—safely and at their own will—were important. Wil and Orv wanted to fly, but they were unwilling to take chances that might result as Lilienthal's and Pilcher's experiments had resulted. And they had patience to

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work until they were satisfied they had eliminated the danger.

So the habit of the public in general, of considering anybody who spent time on flying machines a little bit “cracked,” did not bother them. Perhaps they even snickered between themselves at it. And they kept on studying.

They concluded, in time, that there was actually but one main problem for them to solve. That was the problem of balancing and steering a flying machine, once it was launched into the air.

“We know that big kites—that’s all flying machines are—will rise,” they reasoned. “We know that their wings can be made of sufficient strength to hold their own weight and the weight of motor and operator, and at the same time of sufficient lightness to rise from the ground.

“And we know that it is possible to build engine and propellers of sufficient power and low enough weight to take a machine into the air. Maxim, with his four-ton biplane, did that.

“But where Maxim failed, and where every other inventor and experimenter has failed, is in steering and balancing. That is the question we must solve. When that is done, the aërial age

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will be at hand, for all other difficulties are of minor importance."

So the introductory part of their work was completed—the part that told them what their job was to be. Now the task facing them was to find the answer to the question they had raised.

"In order to know how to balance a plane in the wind, we must know how every kind of plane, and curved surface as well, acts when the wind blows against it," Orv said.

They procured tables of air pressure—tables worked out by Lilienthal and Professor Langley in years just past, by scientists of the French Academy in the eighteenth century, and by the Aëronautical Society of Great Britain more recently—and worked over them. But they could not satisfy themselves completely with other men's figures.

"Let's do some experiments of our own," suggested Wil.

They let pieces of paper flutter through the air, to see what effect various foldings and cuts had on them. They took tiny pieces of cardboard and bent and cut them into every conceivable shape. They used little sheets of metal as well. They held or balanced these sheets in front of streams of air blown through a blow-pipe, and

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observed the things that happened to them. And they got such varied results that the task before them became daily more Gargantuan.

For the pressure of currents of air of varying forces and directions, they learned in these and later experiments, was entirely different on squares from that of the same currents on rectangles. The same variation was true of circles, triangles, ellipses—both as contrasted with squares and with each other. Arched surfaces differed radically from planes, and differed among themselves according to the degree of curvature. “True arcs” of circles showed results different from parabolas; various parabolas had different tendencies.

Moreover, thick surfaces behaved differently from thin; a plane with its forward edge thicker than its rear edge seemed to be not even a distant cousin to an identical plane reversed with respect to the air current. Some surfaces were most efficient—that is, obtained the greatest lifting power from the air current—at one angle, others at entirely different angles. Even the shape of the edge made a difference ——

“——and I can think of about a thousand possible edges!” pondered Orv, ruefully.

CHAPTER XII

OTHER MEN'S MACHINES

WIL and Orv Wright had never seen a man-carrying kite, or glider; they were able to find only a few photographs of the machines of Lilienthal, Pilcher, Chanute, and Stringfellow. But they soon became familiar with every variation of design worked out by each of these men, and a dozen others.

The "center of pressure" was what engineers had been trying to find in the planes and curved surfaces they were studying—that is, the point at which the upward pressure of the air on a surface centered to exert its force. What they at first wanted to do was discover the most satisfactory method of making the center of pressure correspond with the center of gravity, or downward pull. If the upward and downward pulls were equalized and kept in such position as to balance each other constantly, the worst of their problems would have been solved.

Some experimenters, seeking an answer to this problem, had proceeded to put a kind of "pendu-

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lum" on their machines—a device to keep the center of gravity always low. This was intended to act somewhat as the basket of a balloon acts—to hang low and keep the wings always above it. But anybody who has ever seen a balloon in flight knows how widely, at times, the basket swings—yards from side to side, ever oscillating.

"Right there," decided the Wright boys, "is the difficulty with the pendulum system. Even though it would tend to maintain lateral balance in a machine, it would be continually oscillating and waving. That crosses it out. It would destroy every vestige of stability."

Two kinds of balance they had to think of—lateral balance and fore-and-aft balance. The terms explain themselves: lateral balance is obtained when the wings of the machine tend to hold themselves level, drooping neither to one side nor to the other; fore-and-aft-balance when the nose of the plane tends to stay where it belongs, rather than to change places with the tail, allow the machine to plunge head first, or tail first, or upside down.

A system that at first seemed more satisfactory, in Wil's and Orv's eyes, than the pendulum balance was what is known as the dihedral angle machine. A dihedral wing is one that is not flat,

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but has a very slight upward flare from the center of the wing. A plane built on this scheme makes a very wide, flat V with its wings.

"In theory," the Wrights wrote later, in a joint treatise on their investigations, "this was an automatic system—one that tended to keep the machine in balance at all times (in lateral balance, that is). But in practice it had two serious defects; it tended to keep the machine oscillating and its usefulness was restricted to calm air.

"In a slightly modified form the same system was applied (by some experimenters) to the fore-and-aft balance. The main plane was set at a positive angle, and a horizontal tail at a negative, so that they formed a second wide V with relation to each other. The theoretical center of gravity of this V was put far forward.

"But, as in the case of lateral control, there was a tendency to constant undulation, and the very forces which caused a restoration of balance in calms caused a disturbance of balance in winds. Notwithstanding the known limitations of this principle, it had been embodied in almost every prominent flying machine which had been built.

"After considering the practical effect of the dihedral principle, we reached the conclusion that a flyer founded upon it might be of interest from

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a scientific point of view, but could be of no value in a practical way. So we discarded it as we had discarded others."

For the brothers had become hard to please. They wanted to know what others had used—but chiefly so as not to use the same things themselves. They were determined, when they got to building their own glider, to avoid all the defects their predecessors had permitted to creep into their machines.

It was about this time that they commenced their correspondence with Octave Chanute in Chicago. Chanute's experiments had ceased; but he had great stores of knowledge and statistics. Moreover, Wil and Orv were coming to consider one of the gliders Chanute had built, a double-decked machine on the superposed planes plan suggested by Wenham in England, perhaps the best suited to their own purposes.

By 1899 and early 1900 they had come to a good many important conclusions. One was that this Chanute type of biplane, with slightly curved surfaces, was the machine they wanted to try first. Another was that some new method of guiding and balancing must be found—a method differing completely from the body-shifting Lilienthal and Chanute had employed. A third,

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that the tails other men had used were of no use on a glider.

And they had made two particularly peculiar decisions—decisions that called for ridicule from anybody who knew of them.

The first was that they would build a machine that would *not* tend to right itself.

The second was that they would make the wings of the machine flexible instead of rigid, thus permitting the operator to change their shape during flight!

CHAPTER XIII

THE FIRST GLIDER

“**W**HAT we want to build,” one of the brothers had puzzled after a long evening of poring over records and tables and figures, “is not a machine that will itself tend to assume an ‘upright’ position, but one that is as inert as we can make it—that will show a minimum of effect to a change of direction or speed.”

At first blush this revolutionary idea sounded little short of ridiculous. Build a machine that will *not* tend to right itself! But it is easily understood. For Wil and Orv planned, first of all, to get their machine into the air in an upright position; then, if it was “inert”—if its tendency was to hold its position, whatever that position might be—it would remain upright under normal conditions. Not so ridiculous, after all.

This law was evolved only after long discussion, hours of study and argument that sometimes bordered on the bitter. For it frequently happened that the brothers had diametrically op-

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posite views of a problem—when the problem first presented itself.

“The way to obtain stability,” Wil might say, “is to use wings with their tips coming to a point like birds’ ——”

“To a *point*!” Orv would break in, indignantly. “If we want this machine to be stable, the last thing we should do is bring the wings to a point ——”

Then for an hour—or two or three—they would argue heatedly and learnedly and with dozens of highly technical reasons, until ——

“I guess you’re right,” Wil would say. “Pointed wings aren’t what we ——”

“They aren’t!” would be Orv’s vigorous interruption. “They certainly *are*! Didn’t you just prove it yourself?”

Then they would find the eyes of Bishop Wright and their sister Katharine twinkling amusedly at them, and they would break out into roars of laughter—for each had convinced the other, and apparently their problem was as badly muddled as ever.

But it wasn’t. A few moments’ less heated consideration, then, would invariably discover where one had been right and the other wrong,

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and eventually the answer to the puzzler would emerge.

"By making our machine as inert as possible," the brothers explained later, "we planned to reduce the effect of wind gusts to a minimum. We decided we could do this in fore-and-aft stability by giving the planes a peculiar shape, and in the lateral balance by arching the surfaces from tip to tip, just the reverse of what our predecessors had done.

"Then, by some apparatus worked by the operator, we planned to regulate the balance, restoring the machine to an upright position if it should be thrown out."

The shape of the planes was rectangular, three times as long as they were wide—giving them what is known as an "aspect ratio" of three to one—with slightly rounded ends. They were arched, as the brothers planned; but instead of using the degree of camber, or curvature, recommended in Lilienthal's writings—one inch of curve for twelve inches of surface—they used a lower degree—one in twenty-two.

It was, from the tables and machines they had studied, comparatively easy to plan a machine that would achieve the inertness they desired. But this very inertness made vital the success of

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some scheme for controlling the plane—for restoring it to both lateral and fore-and-aft balance when it dipped too far forward or too far to one side.

The device for maintaining the fore-and-aft balance was also relatively easy to plan.

"A couple of planes, much smaller than the main pair, set out in front and capable of being regulated from the driver's position, should act not only as balance controls, but also as elevators," the brothers decided.

So the front-elevator theory—the theory that later was to lead the French to call Wright airplanes "duck-planes," or *canards*, because of the long "neck" in front of the main body—was adopted. It is easy to understand its working. The main planes, say, are set at an angle of three degrees from the level; for level gliding the adjustable front planes will be set at approximately the same angle, so that each has the same relative amount of upward pressure under it. But it is desired to rise, and the front planes are tilted to a higher angle. The air forces them up, and they thereby increase the angle of the main planes; for they, themselves movable, are attached to the machine by rigid arms.

There was a double advantage to this type of

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fore-and-aft balance control, Wil and Orv figured. It gave them not only the main planes, but also the elevators as bearing surfaces. Had the elevators been set behind, the reverse would have been true; to increase the angle of the main planes, the elevators would have had to be turned in the opposite direction, so that the air pressure on them would have been downward.

"Figure it out this way," Orv once explained to a friend. "Take a ruler and call that the main plane. Take a pencil, laid at right angles across the center of the ruler, and call that the frame holding the elevators. It is, theoretically, attached to the ruler rigidly. You want to increase the angle of the 'main plane' a little. If the elevators are in front—at the front end of the pencil—raise that end; if they are behind, lower the back end of the pencil a little."

The question of lateral balance was not so easily answered. Lilienthal, Pilcher, and Chanute had met it by a system of body shifting. If Chanute's plane had tended to dip to the right, he had quickly slid his body to the left; then, as the plane became steady again, he had slid back to center. He and other exponents of this system had also guided their machines up and down by body-shifting.

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"But this method," the Wrights declared later, "did not seem to us capable of expansion to meet large conditions, because the weight to be moved and the distance of possible motion was limited, while the disturbing forces steadily increased with wing area and with wind velocity. In order to meet the needs of larger machines, we wished to employ some system whereby the operator could . . . obtain from the wind forces to restore the balance which the wind itself had disturbed."

As the forces obtainable for control would necessarily increase in the ratio of the disturbing forces, they reasoned, the method seemed capable of expansion to an almost unlimited extent.

But that was all theory. In practice, what was this method to be?

Mark Sullivan, in a newspaper account, tells how they found the answer.

"After dinner one evening in 1899 Wilbur was alone in his bicycle shop. Business was slack, and to pass the time he idly picked up an empty cardboard box which had been left by the purchaser of a bicycle inner tube. This box, oblong in shape, was not dissimilar from the biplane glider evolved by Chanute, which was the type that, in the opinion of

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the brothers, offered most promise. Wilbur noticed he could twist the box between his hands, distorting its surfaces. Holding it before him, he twisted it so that the surface on the right side forward had a downward inclination, and that on the left side an upward inclination.

"The idea suggested itself: Could not the surface of a glider be warped in the same manner, thus achieving a method for lateral balance based on the application of varying wind pressures on either wing as desired?

"When Orville passed by the shop on his way home he found Wilbur sketching a system for warping the glider wings in the manner suggested by the tire box. That forgotten evening in a bicycle shop in Dayton, when two earnest men became excited over the potentialities of a twisted cardboard box, marks more than any other event the moment when the secret of flight was discovered."

And so, almost as soon as the idea for this "wing-warping" had come to them, the brothers were working over the difficult question of applying it in practice. That was no easy matter. An

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airplane wing was designed primarily for strength and rigidity; the plans Wil and Orv had studied had these two features as carefully worked out as engineers and mechanics could work them. And now they were seeking to increase the complexity of the problem.

"We must keep the strength of the Chanute wings," Orv summed up the task before them, "and we must keep the rigidity of all except the wing tips. But the tips we must make strong, and perfectly firm in their attachment to the rigid portions—and yet capable of being bent easily, at the will of the operator!"

Eventually the brothers discovered the solution. What they referred to later, with characteristic brevity, as a "happy device," was arranged to warp the two superposed surfaces "in a most unexpected way." Thus it was possible to present the right-hand ends of the wings with a rear corner of each bent down, and the left-hand ends with rear corners bent up, or *vice versa*. And the result, obviously, was that tendencies to dip to right or left could be controlled by proper manipulation of the wings. For, with the wings "warped" as described above, the wind on the right end of the wings, striking downward-

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angling corners, exerted an upward pressure; on the left end, striking upward-angling corners, it pressed downward. A tendency of the whole machine to dip to the right, then, could be easily controlled by such "warping."

CHAPTER XIV

READY TO FLY

THAT put most of the theory out of the way.

Now, after four years of nothing but study, the Wrights were sure enough of their conclusions to trust their lives to a machine they felt sure would do what they desired of it.

They needed wind. Not just any wind, but exactly the right kind of wind. A steady wind, and one that did not often go to high velocities.

The reason for this particularity about winds was that they had decided to build a glider with about two hundred square feet of wing surface, and the Lilienthal tables of air pressure, by which they expected to operate, said that such a machine would be held aloft by a wind of from fifteen to twenty miles an hour. Thus, if they could find a place where such a wind was fairly common, they might be reasonably sure of plenty of practice.

"To know how to ride a fractious horse," Wilbur Wright had said, "you have to ride him." And, "Orv and I believed that, if some method of practicing by the hour instead of by the second

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could be found, there would be hope of solving the problem."

So they had to know about wind, and they wrote to the United States Weather Bureau.

"Where," they demanded, "can we find a wind of moderate but fairly constant velocity?"

That wasn't such a hard question for an office with so many statistics and charts and records as the Weather Bureau had. It answered promptly:

"Go to Kitty Hawk, North Carolina, just north of Cape Hatteras," directed the letter. "Dare County, there on Albemarle Sound, always has a wind. It should be just the place you want."

The answer to that wasn't quite so easy. North Carolina was a long way from Dayton. And Cape Hatteras, to Wil and Orv Wright, was nothing but a name vaguely—and perhaps amusingly, to these quiet men who found a good deal to smile about—connected with storms and shipwrecks.

But there was \$5,000 in the bank. The "off season" in the bicycle business—the fall of 1900—was approaching. This enthralling sport the boys had taken up was far too interesting now to be given up merely because of threatened expense.

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"We've studied and worked four years for the chance to get into the air," Orv said. "Think anything could keep us from going to this Kitty Hawk place?"

The financial problem, they discovered, was not the only difficulty in going to the "Kitty Hawk place." That particular corner of North Carolina was one of the loneliest and most inaccessible spots in the United States.

In later years a newspaper correspondent who was assigned to visit the place told of the difficulties he had in getting there:

"Kitty Hawk Beach is, you might say, at the end of the world. You go to Norfolk, Virginia, then down into Carolina and across the corner of the Dismal Swamp to Elizabeth City. Then, if you arrive before the early afternoon, you embark on a sort of converted oyster-boat for a six-hour chug down the Pasquotank River and across Albemarle Sound. At nightfall you reach Roanoke Island and the ancient town of Manteo. . . . At five o'clock the next morning you catch the launch that chug-chugs out to Nag's Head and Kitty Hawk. . . . Then comes the four-mile tramp through the woods to the Kill Devil sand hills," where many of the later gliding experiments were made.

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Wilbur Wright was thirty-three years old, Orville twenty-nine, when they departed for Kitty Hawk. Mature men, these bicycle-builders, with labor-hardened hands and exercise-hardened muscles. They had little to say as they made the hard journey with their boxes and bundles of materials, their sheaves of plans and charts and statistics, their cases of tools. But their enthusiasm grew; in eagerness they were more like seventeen-year-olds than men.

The barren cheerlessness of the swampy, wooded district about Kitty Hawk, where they were to make their experiments, did not lessen their impatience to get to work. They camped in what seemed a favorable spot—a level area comparatively free from trees—and started to build the first glider.

Most of the early Wright gliders were made with a framework of pine, with ash as the front edging of the wings. In the construction of this first machine they had decided on certain changes from the Chanute plans, their principal guide. Chief among these changes was the transfer of the forward main cross-piece of the wing frames to the extreme front edge. By this they expected to give greater strength to the “cutting edge” of the wings.

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Another improvement over earlier gliders—one that forecast the theories of plane-builders of later years—was the encasement of all cross-pieces and ribs of the surfaces in the covering cloth, a good grade of muslin.

“We want to reduce the wind resistance as much as possible,” they pondered. “If we make the surfaces smooth instead of broken up by a hundred little bars and ribs, that will remove a good deal of the area presented directly to the wind.”

Even then the Wright glider of that day looks like a maze of wires and struts and cross-bars as compared with the stream-lined machines of twenty-five years later. But that business of covering ribs was a move along the right line.

The third improvement of importance, aside from the radically new theories Wil and Orv were incorporating in their machine, was a rearrangement of the wires used in trussing the two surfaces together which rendered it possible to tighten all wires simply by shortening two of them.

What the brothers believed to be another advantage of their scheme was the position the operator of the glider was to assume.

Lilienthal, Pilcher, and Chanute had all ridden

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in an upright position—a position that presented the entire surface of their bodies to the wind.

“Let’s see,” figured Wilbur. “How much power does that mean?”

The surface of the operator’s body opposed to the carrying wind was about five square feet, he discovered. And that meant, in a wind of the strength on which they were figuring, about five-eighths of one horsepower.

“More than half a horsepower lost, then. For his body is resisting the wind to that extent. There’s an obvious way to avoid that loss.”

They chose the obvious way. With the glider’s operator prone on the lower wing, they discovered, only one square foot of surface would be presented to the wind. A full half horsepower would be saved.

“We’ll fly prone,” they decided.

By early October of 1900 the first glider was completed. Its surface was a little smaller than they had originally planned; it had only 165 square feet instead of the 200. This was because they had experienced difficulty in obtaining exactly the materials they wanted.

At last came the evening when, as the Carolina sun set behind blue hills to the west, Wil and Orv

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knew that their glider would be ready for its initial trial the next day.

It was a nervous evening in the lonesome little camp. Neither of the Wright brothers was given to worrying, and they did not worry now. But if they were not anxious, they were eager. They had final looks at their tables of air pressure; as the light died away they had a final look at the huge white kite fastened firmly in place near their flimsy shelter, awaiting only a few final nut-tightenings and wire testings to be officially called fit for trial.

There was an unspoken question in the eyes of the two as they looked at each other. Would it work?

"Well," laughed one of them, shortly, "we'll know tomorrow ——"

"—— provided the wind is right!" supplied the other.

Nobody else was particularly interested. Occasionally there had been a visitor at the camp—a native of the little Kitty Hawk settlement closer to the water's edge, a member of the life-saving crew at the Kill Devil Hill station, a casual passer-by (though there were few passers-by at that lonely spot). But this was no handicap in the eyes of the Wright brothers. The fewer they

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had to ask questions during those first experiments, the faster they could work!

And so, with the wind souging through the few trees near them, they went to bed on that October night, a question in their minds. Would there be a wind the next day?

And the machine they had spent so much time to make right in every particular—would it fly?

CHAPTER XV

THE BIRD TAKES WING

SUCH a wind as greeted Wil and Orv Wright when, early the next morning, they tossed off their blankets and got up!

It wasn't a gale; but it wasn't the twenty-one-mile wind they had hoped for, either. It was blowing a good thirty miles an hour, and it gave no signs of abating.

"There'll be no free glides today," said one of the brothers, "if that keeps up."

But they had a plan for use of the machine even in such a wind. So they went carefully about the delicate job of making final adjustments, tightening a stay here, testing the fastening of the muslin there, making sure the controls of the flexible wing tips were in order, looking to the action of the adjustable front rudder, examining joints and splicings and struts.

Perhaps never afterward was there quite such trepidation in the hearts of these two men as they performed this task. It was a task they performed many times afterward—never did either

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brother go into the air without a thorough examination of his plane—but this was the first time, and the first time was different. They were testing against theory—testing for strains they anticipated empirically.

Had they figured properly? Were their plans of construction and their theories of air pressure adequate? Would the big kite stand the trial to which they were about to put it?

They believed it would. And they went ahead.

Eventually every test was completed and every adjustment was satisfactorily made.

“Now,” said Wil, “we’ll see.”

The machine they had built, of 165 square feet of wing area, should have been supported, the Lilienthal tables assured them, at an angle of three degrees from the horizontal in a wind of twenty-one miles an hour. A wind of thirty miles an hour, they knew, had more than twice the lifting power of the “average” they had chosen; so, theoretically, the glider should have remained aloft at an even flatter angle.

But they still knew nothing about actual management of a machine in free flight. If they could have learned that without practice—if the secret of riding the bucking horse could have been learned by sitting on a fence—there would

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have been no need for their experiments. Since they had not this knowledge, they had no idea of attempting to handle a machine in free glides until aërial conditions were precisely what they wanted.

So they applied the alternative plan.

One of the brothers (which one made that first attempt may never be known, for in all their accounts of it Wil and Orv always used the vague pronoun "we," in strict accordance with their insistence that neither deserves more credit than the other) took his position in the glider, stomach down on the lower wing, neck craned forward, hands gripping the handles in which the two sets of control wires ended.

The other brother loosened the ropes which held the kite firmly to the ground. He tested the fastening of another rope, one attached to the lower frame of the machine just underneath the center of the lower wing; tested its ground fastening, too. He turned the whole machine slightly, so that its long protruding neck pointed directly into the wind.

"Ready?" he said, tensely.

"Ready!" was the cool reply.

He lifted the front of the machine slightly, urging it forward as he did so. The man on the

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lower wing pulled his elevator control wire, and the rudder planes tilted a little.

And the big kite with its human burden, shivering a little in the gusts of wind, went up!

It rose slowly, straining against the one rope that held it from being blown backward or upside down as the rope was paid out. A few feet above the ground it mounted; then the rope was made fast and the glider flew—for all the world a big kite much like those Wil and Orv Wright had flown on the Commons in Dayton years before.

But it didn't behave just the way the brothers had expected it to do. "An angle of three degrees," the Lilienthal tables had promised them; but even in a wind of thirty miles an hour the wings did not remain at so small an angle, and at twenty-five miles the wind held the machine twenty degrees from the level, a decided slope.

Something wrong there. What it was they would have to find out.

There was plenty of cause for rejoicing, in spite of this one disappointment. For, soon after the machine rose into the air, it dipped abruptly to the left, the right wing rising sharply. The operator pulled the wing-warping lever, tilting the corners of this wing up, the corners of the

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left wing down. Immediately the machine righted itself—returned to an even keel.

And the slightest variation in the angle of the elevators brought with it the desired answer from the main wings. The machine's angle was too great to allow it to be brought to the ground by use of the elevator; it had to be hauled down like any kite. But the Wrights knew two things—the elevator principle was right, and the wing-warping principle was right.

"It's a lot more effective to steer and balance by these devices of ours than by the body-shifting system," they noted. "At any rate, we've made that much progress."

On succeeding days the wind was not always so powerful as it had been when they made that first trial, but they elected to continue testing the machine as a kite, nevertheless. Sometimes, if the wind made it possible, the glider bore one of them aloft; on other days, when the breeze was too slight, they sent the machine up at the end of its rope without an operator. On these days they manipulated the controls by means of lines attached to the handles and worked from the ground; and they found that the glider could be flown almost as well this way as with a man aboard!

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"The results," Wilbur said later, "were very satisfying; yet we were well aware that this method is never wholly convincing until the results are confirmed by actual gliding experience.

"Before we started gliding, however, we turned our attention to making a series of actual measurements of lift and drift of the machine under various loads. So far as we were aware, this had never been done with any full-size machine. . . . It appeared sadly deficient in lifting power as compared with the calculated lift of curved surfaces of its size; it did not at all measure up to our expectations.

"This deficiency we supposed might be due to one or more of the following causes:

"That the depth of curvature, being only about one in twenty-two instead of one in twelve, was insufficient;

"That the cloth used in our wings was not airtight;

"That the Lilienthal tables were themselves in error.

"At any rate, we decided to arrange our machine for the following year so that the depth of arch in the surfaces could be varied at will, and their covering air-proofed."

Already, then, the two scientists were planning

for their second machine. As it happened, the two changes they decided to make to correct the errors of that first glider were the two of least importance. They were to find out that the third "possible error"—fault in the Lilienthal tables—was the one on which they needed to work.

Meanwhile, they had further experiments to make this fall.

CHAPTER XVI

TWO MINUTES OF GLIDING

IN ONE respect the Kitty Hawk camp site selected by Wil and Orv was not happily placed. That they realized when, their knowledge of the performance of their machine bolstered by the flights it had made at the end of a rope, they sought a hillside from which to make free glides.

The country about their camp was too gentle in its slopes to be useful in gliding. They needed a decided incline, so that, when the machine was launched into the air and started "sliding downhill" on air currents, it could follow the slope of the ground and thus remain in the air longer.

Their search for such a place ended at the Kill Devil sand hills, four miles south of the camp. The slope they selected rose more than one hundred feet from the flat sand below, at an inclination of about ten degrees, its face toward the northeast.

So the glider had to be moved the four miles from the camp to the hill, through North Caro-

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lina woods and over sand. It was not so stupendous a task, for the machine, in spite of its fifteen feet of wing spread, was extremely light. Moreover, they had occasional assistance. Boys from the scattered homes at Kitty Hawk and Nag's Head, sometimes men from these same homes, and more often members of the Kill Devil Hill life-saving station, were commencing to take interest in the "crazy" experiments going on near them. And although they hardly believed anything could come of such ideas, they were not hesitant in lending hands to the two inventors from the North.

Wil and Orv did not, either this year or in those immediately following, seek to escape notice in their experimenting. They had chosen Kitty Hawk not because of its isolation, but because of its winds. They did not at all object to the casual, friendly interest these North Carolinians took in their work, even though the watchers did smile covertly now and then; and they often welcomed the assistance they were offered. Building a flying machine and learning how to fly it were still sport to them. Why begrudge anybody the opportunity of watching?

On the day they finally reached the top of Kill Devil Hill with their glider the wind was too

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strong to chance—twenty-five miles an hour. So that night the glider was staked and roped down while its builders went back to their camp. Delay was not pleasant, for the brief vacation the boys had allotted themselves was coming to an end. "But," declared one of them, "better put things off a day than—end them permanently!" And the next day a much milder wind, one of only fourteen miles an hour, greeted them.

"We ought to be able to make it go today," decided Wil. "Want to try it?"

The original plan the two had worked out was this: The operator was to seize the machine as best he could, run a few steps down the slope with it to gain initial velocity, and then assume the horizontal position on the lower wing. But one of the self-appointed assistants was handy, and the brothers decided on a system that proved far more satisfactory.

The man who was to operate the plane would take his position on the wing; then his brother would take one end of a wing and an assistant the other, and the two would start the machine down the hill and into the wind until it floated itself on the up-pushing wind.

This was tried. It worked. That first flight of the first Wright glider was not a long one, nor

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was it spectacular; but in its lack of spectacle—in its calm, bird-like soar into the air, its calm “slide” down air currents along the slope of the hill, and its final calm settling to earth like a duck to water—lay its success. For the wing-warping kept it perfectly steady in the wind; the front elevator seemed to work exactly as they had hoped—the machine responded to its slightest movement almost abruptly. And the landing was effected without damage to machine or operator.

It was a very happy pair of Wright brothers then, after the machine had come to earth and the man at the top of the hill had raced down to greet the man at the bottom.

“She flies!”

“And did you see the way she landed!”

“She answers her controls like a bird.”

“Let’s try her again!”

All in all, a dozen glides were made that day. In addition to the changed method of taking off, the trials developed a different kind of landing from that originally planned.

“When it came time to land,” Wilbur explained, “the operator was to resume the upright position and alight on his feet, after the style of other men’s gliding experiments. But in these trials we found it was entirely practicable to land while

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still in the prone position. Although landings were made while moving at speeds of more than twenty miles an hour, neither machine nor the man in it suffered injury."

That a machine could be built so sturdily came to be an integral part of the figuring of the Wrights when, later, they started to plan landing-gear for power planes.

Wilbur, in an article he wrote two years later, tells of the further discoveries those first twelve flights brought forth.

"The slope of the hill was about one foot in six. We found that after attaining a speed of about twenty-four to thirty miles an hour with reference to the wind, or ten to sixteen miles an hour over the ground, the machine not only glided parallel to the slope of the hill, but even greatly increased its speed. Thus we knew that, when we felt it safe to rise higher above the surface of the ground, the machine would easily glide at a somewhat smaller angle than the ten degrees it had been doing—that is, it would continue to ride down an air current of that speed, fourteen miles an hour, even though it were not riding at quite so steep an incline.

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“With these glides our experiments for 1900 closed.”

With two minutes in the air, then—and those two minutes spread out over twelve different glides—Wil and Orv had to content themselves. A decided setback, it seemed, for the men who had aimed at learning all about managing a glider in the air by substituting hours of practice for the seconds of other men!

But it was time for them to return to Dayton. Their vacation time was ended; they had a bicycle business back there to attend to; and as they dismantled the glider and packed it into crates, as they stored up tools and camping outfit, as they bade farewell to the few boys and men who had watched them, they were not at all discouraged. Rather they were deeply pleased.

“You’ll see us back next year,” they promised their Kitty Hawk friends, “and you’ll see some new tricks!”

They had, after all, more than sufficient reason for feeling their progress satisfactory.

“We had set out,” Wilbur wrote, “with revolutionary theories on many points, and an entirely untried form of machine. So we

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were glad to get back to Dayton without having had our pet theories completely knocked in the head by the hard logic of experience, and our own brains dashed out in the bargain!

"Everything seemed to us to confirm the correctness of our original problems. Practice, we felt more keenly than ever, was the real secret of flying, and we were more than ever determined to get that practice. We had proved to our own satisfaction, too, that it was practicable to fly prone.

"More important scientifically, however, were the proofs we had obtained of three other theories. We had shown that a smaller surface, such as our elevator plane, set at a negative angle in front of the main bearing surfaces, or wings, will largely counteract the effect of the fore-and-aft travel of the center of pressure. In other words, when the center of pressure in the main planes traveled forward and they dipped, an increase of the angle of the elevator plane tended to offset this and bring the whole machine back into fore-and-aft balance.

"We knew that steering up and down,

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through this elevator, could be attained without movement of the operator's body.

"And we had proved that twisting the wings so as to present their ends to the wind at different angles is a more prompt and efficient method of maintaining lateral equilibrium than that of body-shifting."

So it was with enthusiasm that they described to the few in Dayton who were really interested—to Bishop Wright and to Miss Katharine, to Jammes Sines and perhaps the workmen in their bicycle shop—the results of their experiments.

And it was with eager pleasure that they took pencils and paper, rulers and compasses and tables of pressure, and went about figuring dimensions and plans for the new machine they were to build.

"The Wright boys still tinkering with flying machines?" asked Dayton wiseacres. "Remember that crazy tandem bicycle they used to have? They better stick to their knitting."

"I wonder," said Orv one day early in 1901, "whether we can't get down to Kitty Hawk earlier in the year this time—say in July?"

CHAPTER XVII

CHANUTE'S COMMENT

FOR the Wright boys the months that followed their return to Dayton in 1900 were no more than a period of probation until they could go back to Kitty Hawk the next year.

They decided to make few changes in design of the machine they were to build for the 1901 experiments. It would be exactly like the first glider in theory and method of operation. But that first machine had had one great difficulty—its lifting power had been far lower than the brothers had desired. This fault they wanted to remedy.

“We’ll increase the size of the machine, and increase the surface curvature to one in twelve—the same camber Lilienthal used,” they decided. Their first machine had had a curvature of only one in twenty-two.

“And we’ll use a specially prepared muslin on the wings so that we won’t lose any wind-power by having air go through.”

So plans were drawn up for a machine nearly

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twice the size, in wing area, of the first glider. The new wings were to be twenty-two feet long and seven feet wide; the total surface of the two, therefore, would be 308 square feet. This would make the glider of unheard-of size. Their first machine, like Pilcher's, had had 165 square feet of wing area; Lilienthal's had had 151; Chanute's only 134.

"Other experimenters," pondered Wil, "would say that we were crazy—that such a big machine we can't control——"

"But other experimenters," Orv reminded him, "didn't have a control system such as we've evolved. They tried to steer and balance by crawling back and forth in their machines, and naturally the bigger the machine the harder to crawl fast and far enough. Our system ought to be just as good in a larger-surfaced machine as in the smaller, because the portion of the wing to be warped increases exactly in ratio to the increase in wing size, and ought to have just the same effect."

On that theory they proceeded. According to the Lilienthal tables—the accuracy of which they seriously doubted, particularly since they so often varied from other air pressure figures—a seventeen-mile-an-hour wind would support the big

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machine at an "angle of incidence" of three degrees.

But they had figured, the year before, that their smaller glider would be similarly held up by a twenty-one-mile wind. And they had suffered badly shattered hopes.

"We'll know," said Wil, grimly, "when we try it."

Meanwhile it was becoming known here and there, through their correspondence with Chanute and other aëronautical experimenters, that they were working along new lines. Chanute continued to take a deep interest in the brothers, and they asked him to visit them at their Kitty Hawk camp in the summer. A young Pennsylvanian, Dr. A. G. Spratt, was another who thought their conclusions worth examining. Dr. Spratt had made a number of "valuable investigations of the properties of variously curved surfaces and the travel of the center of pressure thereon," and the Wrights were eager to talk with him about his work.

About the middle of July, more heavily laden with materials and tools than they had been the previous year, Wil and Orv arrived in Kitty Hawk. At first, as they commenced to build the new glider, they had only a two-man camp;

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but it was soon increased to four. E. C. Hufaker, a Tennessean who had been in the employ of Octave Chanute and who was an experienced aeronautical engineer, as aeronautical engineers in 1901 went, joined them, his services "loaned" by Chanute. Not long afterward Dr. Spratt journeyed down to North Carolina from Pennsylvania, eager to watch the experiments of these newcomers in the aeronautical field.

The four camped and worked together, and rapidly the machine took shape. There was another project under way, too—a building in which to house the glider. Camp this year, incidentally, was near the Kill Devil Hill, not on the site of the 1900 camp, four miles distant from the hill. Two more assistants appeared as the building went up—Dan Tate and W. J. Tate, two residents of Kitty Hawk.

The building was made with the simplicity that characterized everything the Wrights constructed. It was a simple frame shed, sixteen feet wide, twenty-five feet long, and—at its eaves—five feet high. Both ends were hinged eave-high, so that they could be opened the full width of the building and swung out as awnings, permitting the shed to be used as workshop as well as hangar.

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The completed plane had a wing spread of twenty-two feet, and a length, from the front of the extended rudder to the rear of the wings, of fourteen feet; it was just less than six feet high. So it could be housed quickly and easily, sliding under the raised door of its shed without change or adjustment.

To the Wrights, at that time, such an arrangement for the shed seemed novel and worth particular mention in descriptions of their 1901 work. To aëronauts later, in the days of tremendous hangars with electrically operated doors capable of swinging open at a touch to admit gigantic airships, any other arrangement would have seemed unthinkable; but in 1901 aircraft were not common, and such a convenience as a glider-size door was worth telling about!

The machine was ready for its first flight on July 27th. It had been decided to follow last year's scheme of flying—kite-flights until the performance of the new glider was assured, then free flights. Like last year, the first feats of the machine were disappointing.

The tendency of the plane was still to assume a much greater angle than the Lilienthal tables had promised. Its lifting power was far below what it should, theoretically, have been. And

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the elevator plane, or rudder, had not nearly the effectiveness it had shown on the earlier machine. The plane had responded quickly to the veriest touch of the rudder in 1900; this year it refused to show more than one-fourth as much effect. The wing-warping principle proved to be just as good on the larger machine as on the smaller—that was solace.

And the words of Octave Chanute, who came to spend a week at the camp early in August, were further comfort.

“There’s no essential technical fault in the construction of the plane,” he assured Wil and Orv at once. “The fault lies somewhere else—somewhere you must discover.”

This was praise indeed from the man who, the brothers felt, had carried his investigations in many directions farther than any other aëronaut. He was the teacher, they his pupils, in their own eyes. It had been enough that he had considered it worth his while to come down from Chicago to Kitty Hawk.

And his comment gave Wil and Orv hope that soon they might reach their hoped-for goal—the ability to glide at will and to enjoy to the fullest the sport they had taken up. For it was still a sport to them, one that became the more

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fascinating as the few seconds of actual flight they had won showed them the thrill and flair of it.

But the things Chanute told them about their work in the succeeding days brought them up with a start. Sport? If what he said were true, these two bicycle-builders had embarked on a very serious business.

CHAPTER XVIII

DISAPPOINTMENTS—SUCCESSSES

THE first attempts at free flight were no more successful than the kite-flying of this second glider had been.

The initial glide from the top of Kill Devil Hill came to an ignominious end almost before it had commenced. Hardly was the "huge" machine launched into the air, operator aboard, by the two men at the wing-ends, when it proceeded to duck its nose and settle, none too gently, to the ground. Frantic manipulation of the rudder—already proved highly ineffective—did not alter its course.

"There's a good way to discover the difficulty," observed Wil. "Let's try it again."

So, one after the other, time after time, Wil and Orv launched themselves into the fourteen-mile wind. The center of pressure was so far back in this machine, they decided (and they came to a new conclusion, that it tended to travel backward as the surface of the wings was canted

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more and more edgewise to the wind) that the center of gravity must be moved back, too.

That meant moving the position of the operator farther back, and this proved effective. After less than one minute of actual gliding—though this meant hours of preparation and “retrieving” the machine and pondering over its faults—the brothers believed they had found the proper position. And off the big kite went on another hop.

A crazy, undulating flight it proved to be—a few feet of level gliding, then a sudden dive for the ground, corrected just in time by jamming the rudder to its extreme upward angle; a shoot upward, a leveling off; and then the whole procedure over again. But when the glider at last came to earth it was three hundred feet from its starting-point.

“’Ray!” cheered Orv, softly. “Not exactly like a swallow, but before long we’ll bring it to that.”

The next attempt brought with it the most dangerous situation the Wrights had yet met in their practice—the position Lilienthal had always found dangerous, and the one which had finally caused his fatal accident.

The machine not only started off well. It took

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to the wind like a bird, and, to the amazement of the little knot of spectators, started to rise—actually to climb on rising air currents! Wil was in the machine, and Orv was following on the ground, exultantly, as the glider rose. But suddenly he screamed a warning.

“Look out, Wil—she’s stalling!”

For the slow climb of the kite had ceased, and for an instant it was hanging motionless in the air. That meant that it had lost all headway, and a second later, unless something happened, it would crash to the ground with frightful speed. It was this kind of crash that had killed Lilienthal. And Orv was faint with fear as he saw the glider stall.

But the necessary something happened. Wil—the man who had once been a boy so weak from nervous shock that he had to stay at home and read books—calmly jammed the rudder down and edged his body just a trifle to the front. The wind at once took hold and the ship nosed toward the ground—not with deadly velocity, but at a slow lazy gait like that of a yacht at the start of a new tack.

And a few seconds later it settled gently to earth, horizontal throughout its descent.

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There was a gleeful conference between the brothers after that. True, the big kite still did not answer its rudder properly; its angle of incidence was too high; its lift was too low.

"But we've proved that the front rudder scheme has overcome one of the greatest dangers of the old horizontal-tail type of glider," Orv declared.

A little later the proof was even more definitely established. The machine not only stalled high in air. It commenced to move backward, a movement that might quickly have reversed the center of pressure and sent it plunging earthward. Again quick rudder manipulation proved effective. The glider came to earth like a duck to water.

That was the end of the first day's gliding experiments. "On the whole," wrote Wilbur later, "this day's work was encouraging. For while the action of the rudder did not seem at all like that of the 1900 machine, yet we had escaped without difficulty from positions which had proven very dangerous to preceding experimenters.

"After only a few seconds of practice we had made a glide of more than three hundred feet, at an angle of descent of ten degrees and with a

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machine nearly twice as large as had previously been considered safe. We believed we could discover and correct the control trouble."

That was the next problem. In construction the chief difference between the first glider, which had responded readily to its elevator, and the new machine was the camber of wing surfaces. So it was decided to reduce the camber.

This was done simply enough—by trussing down the ribs in such a manner that the wings became somewhat flatter. And when further experiments were made, after this change, the machine answered the rudder movements with all the celerity the brothers could ask. So one of the difficulties was put out of the way.

Glides for the several days following were increasingly successful. The first two attempts after the change in camber resulted in rides of 366 and 389 feet, and others of corresponding length were made. Of more importance, the pilot of the plane found himself able to manipulate his mount almost at will, as long as the "motive power"—the supporting wind—struck his wings properly. He could skim the ground, following undulations of the surface as nearly as though riding on it. He could sail out almost

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on a level with the starting point—at an angle much smaller than the ten-degree slope of the hill—and, passing high above the bottom of the slope, gradually settle to the ground.

The wind on the second day of the trials was of eighteen to twenty-one miles an hour in velocity—great enough so that the careful Wrights were a little doubtful of the advisability of taking the machine from its shed. But they decided at length to risk it, and found it to be eminently safe. Eventually they flew in winds mounting to twenty-seven miles an hour, operating with perfect security at this “hurricane” speed.

It was during these tests that Chanute produced his camera and made a number of photographs—the first pictures of Wright flights.

And it was while they were continuing that he told the brothers the thing that “startled them into seriousness.”

“Your experiments,” he declared, “have produced better results than those of any of your predecessors. In my opinion, you two are the leading heavier-than-air aëronauts of the world!”

It was something like Watt’s idly watching the teakettle lid and envisioning a creature of iron and steam that would move nations. Wil and Orv Wright had been watching—so they thought

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—a machine that was of no other use than to furnish a few hours of pleasure to them. And suddenly they had thrust on them the inevitable fact that they had created one of the scientific marvels of a marvelously scientific age.

CHAPTER XIX

THE WIND TUNNEL

IT PUT a new face on things, somehow. It made out of the Wrights, more or less against their will, aëronautical engineers rather than sportsmen-experimenters. And it caused them to examine the results of their work with new eyes.

They became more than ever scientific in their estimation of their problems; and in time they became completely skeptical of the opinions and theories and calculations of others.

It was a blow, this skepticism. For five years, now, they had been basing every theory, every idea, every design, every move on tables of air pressure and lift and resistance which they supposed to be accurate. They had built two machines with these tables as the foundation. They had spent a good deal of their capital. And now they were forced to believe that there was so much wrong in the "findings" of Lilienthal and Pilcher and Langley and Mouillard that a good deal of their own work must be utterly useless.

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In spite of the successful flights the 1901 machine had made then, "the experiments of that year were far from encouraging," Wilbur wrote. "Although Mr. Chanute assured us that, both in control and in weight per horsepower, our results were better than any that had gone before, we saw that the calculations upon which all flying machines had been based were unreliable and that all were simply groping in the dark. Having set out with absolute faith in existing scientific data, we were driven to doubt one thing after another, until finally, after two years of experiment, we cast it all aside and decided to rely entirely upon our own investigations.

"Nevertheless, the time expended in preliminary study of books was not altogether misspent. It gave us a good general understanding of the subject and enabled us at the outset to avoid effort in many directions in which results would have been hopeless."

And so, feeling almost that they had to start at the bottom again—as indeed they did as far as many basic theories were concerned—Wil and Orv broke camp a second time and returned to the bicycle shop at Dayton.

It was not so enthusiastic a home-coming this time. For they had worked over the accounts of

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their experiments and their findings, and they realized more than ever the tremendous task ahead of them. In a moment of extreme despondency Wil ventured a gloomy prediction.

"Man will not fly for a thousand years," he told his brother, blackly.

They had discovered, through actual experiments, that the "teachings of the books" were wrong about the travel of the center of pressure on a cambered surface. Those first glides with the 1901 machine had shown that it moved slowly backward as the angle of the wing to the wind decreased, with a resultant tendency to dive.

They knew that Lilienthal's tables of air pressure and of lifting power were not reliable. The wind had refused to raise their machine and pilot—one hundred pounds of glider and one hundred and forty of pilot—as they had calculated, from the tables, that it would.

They doubted the accuracy of their anemometer, the instrument to record wind velocity; it seemed to show winds about fifteen per cent above true speed.

They had even discovered a dangerous fault in their wing-warping scheme. It had appeared during several flights when, contrary to expectations, the warping of the plane had "presented the wing

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on one side of the machine at a greater angle to the wind than that on the other side; . . . the machine then tended to turn in a direction just the reverse of what flying the machine as a kite had indicated as the probable reaction. The larger angle gave more resistance to forward motion, and reduced the speed of the wing on that side. The decrease in speed more than counterbalanced the effect of the larger angle. An attempted remedy, the addition of a fixed vertical vane in the rear, increased the trouble and made the machine absolutely dangerous!"

Of all the mass of theories with which they had started, they seemed to have corroborated one by their work. That was the paradoxical Lilienthal principle that pressure actually tends to draw a properly constructed plane forward into the wind. It was to this fact that they attributed the small amount of "drag" or resistance they found.

Wilbur's glum prediction did not bother either him or Orville long. Disliking the idea of extended scientific research, for "we had taken up aëronautics merely as a sport," they knew before they reached Dayton that they could progress no further if they did not supply themselves with accurate and reliable figures on which to base their work.

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"We reluctantly entered upon the scientific side of aëronautics," Wil declared. "But we soon found the work so fascinating that we were drawn into it deeper and deeper."

The obstacles were great. "The standard measurement of wind pressures is the force produced by a current of air of one mile an hour's velocity striking squarely against a plane of one square foot in area. The practical difficulties of obtaining an exact measurement of this force have been great. The measurements by different recognized authorities vary as much as fifty per cent. When this simplest of measurements presents so great a problem, what shall be said of the troubles encountered by those who attempt to find the pressure at each angle as the plane is inclined more and more edgewise to the wind?" Thus complained the brothers.

And so, even though it meant casting out such authorities as the French Academy and Professor Langley, Wil and Orv took clean sheets of paper and started to make their own tables. "The others we found to be little better than guess-work."

During that winter the workshop of the Wright Cycle Company became more than ever an aëronautical laboratory rather than a manufactory

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for so simple a contrivance as a bicycle. For the business of flying was become grimly serious now—how else could the newly named “leaders of their science” take it?

Before long the orderly collection of newly enameled frames, tireless wheels, shiny pedals, and bicycle miscellany that filled the center of the workshop was cleared to make space for a new device. As this machine took shape, it seemed to be nothing more than a square tube, sixteen inches on each side, six feet long. One end was open; at the other was a machine that could be made to whirl a fan at high speed, sending a current of air through the tube.

“What the dickens,” demanded an amazed visitor one day, “has that thing to do with building Van Cleve bicycles?”

Orv smiled. “The only relation that has to Van Cleve bicycles,” he answered, “is that they paid for it. It’s what we call a wind tunnel.”

In the open mouth of that wind tunnel, during the winter of 1901-02, were worked out most of the things the Wrights wanted to know.

They had to go back almost to the unexpert, unanalyzed experiments they had made three, four, five years before, when they had first folded and cut small sheets of paper and let them fall

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through the air. They had to know—to *know*—all about planes and cambered surfaces, triangles and circles, oblongs and squares. They had not only to observe how these things acted, but to translate their observations into pounds and horsepower, feet and miles per hour. And each experiment they had to do dozens—or scores or hundreds—of times in order to eliminate chance of error.

At first they took what they called preliminary measurements on a great number of different-shaped surfaces—more than two hundred different small sheets of cardboard or paper or thin, delicately shaped steel were balanced in the mouth of the tunnel and subjected to wind pressures. Slowly certain facts commenced to emerge.

Among other things, a rectangular plane with an aspect ratio of six to one—six times as long as its width—proved to have more lifting power than one of similar area, but with an aspect ratio of three to one. An important finding, this; for their two machines had been of this less effective ratio.

But these preliminary measurements gave only general laws. What was needed was minute accuracy, great detail, meticulously correct interpolation. And so, in the evenings and the extra

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hours Wil and Orv put in at that wind tunnel and at their desks, they gradually worked out the tables they wanted.

On nearly fifty of the variously shaped surfaces the most careful measurements were taken—measurements of lift, air pressure, resistance—at every two-and-a-half-degree angle from zero (or horizontal) to forty-five degrees. It was no easy task, for many times two successive experiments with apparently exactly similar conditions gave different results; sometimes a dozen experiments gave a dozen answers. But at length careful tables were established—tables on which Wil and Orv felt they could rely thoroughly. For they never considered a figure worth putting down in the book until they could make the experiment turn out again and again in an identical manner.

They took, moreover, measurements of two surfaces in relation to one another—one above the other, one behind the other, and so forth. And they proved the theory whose existence they had suspected since their summer flights, that two superposed planes have not quite the lifting power as the same two planes separately.

“Some strange results were obtained,” Wil wrote in his notebook. “One surface, with a heavy roll at the front edge, showed the same lift

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for all angles from seven and a half to forty-five degrees. A square plane, contrary to the measurements of all our predecessors, gave a greater pressure at thirty than at forty-five degrees. This seemed so anomalous that we were almost ready to doubt our own measurements, when a simple test was suggested."

When Wilbur Wright wrote "was suggested" it frequently meant "I suggested"; for it is next to impossible, in any of his writings about his and Orville's experiments, to find the word "I."

"We made a weather vane with two planes attached to the pointer at an angle of eighty degrees with each other," he went on. "According to our tables, such a vane would be in unstable equilibrium when pointing directly into the wind; for if by chance the wind should happen to strike one plane at thirty-nine and the other at forty-one degrees the plane with the smaller angle would have the greater pressure, and the pointer would be turned still farther out of the course of the wind. This turning should continue until the two vanes again secured equal pressures, which would be at approximately thirty and fifty degrees.

"The vane did just this."

So simply and characteristically as that, Wil

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described the successful completion of an experiment whose result must have pleased the two men greatly. For those were difficult days, and corroboration of their work was not a matter to be passed over lightly.

CHAPTER XX

AGAIN AT KITTY HAWK

AUTUMN of 1902 found the Wright brothers again on the sand hills of the North Carolina coast, this time with plans for a machine which would, they confidently expected, outstrip its two predecessors in every way.

For now, Wil and Orv felt, they were able to go to work on a truly scientific basis. They knew what degree of curvature to give the wings of the new glider. They knew what proportions the wings should have. They knew how much weight the machine would carry, what angles it would assume in varying winds.

They were not, in 1902, struggling in the dark, trying to make unproved figures given them by other men perform impossible feats. They had their own facts to depend on, their own tables with which to work. *They knew.*

They had in mind, too, something which had never taken more than the dimmest kind of shape before. It was figured out somewhat like this:

“The thing that keeps a glider in the air is

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power—the power of the wind pushing up on its wings. When a machine is sliding down an air current it is using wind power to sustain itself but the power isn't often quite enough to keep it up permanently. When it is being flown as a kite, with a rope holding it stationary in the wind, the same kind of power is being applied.

"But Maxim and Langley and Ader have shown, by their experiments, that you can get this power from a motor as well as from the wind—that you can supply your own wind. If this glider works as well as we think it will, we'll have to get busy on wind-manufacturing. Then we'll have a glider that won't have to depend on nature."

Still, they weren't quite ready for a power plane. There were several obstinate problems to work out before they would be satisfied that they had reached a point of safety at which they dared attempt something that seemed likely to present an entirely new set of questions.

So they went ahead on the 1902 glider.

On September 17th it was ready for its trial flights. It had the new aspect ratio they had approved—its length was six, instead of three, times its wing width. It had the wing curvature their

wind tunnel experiments had shown to have the greatest lifting power consistent with control. And it had the wing-warping device that was the distinctive feature of every Wright machine.

But, as experiments commenced and continued, it had something new. It had a tail.

"Positively dangerous," Wil had called the addition of a fixed vertical fin as a means of correcting the glider's tendency to turn as the wings were warped. And yet something had to be done.

"The tail idea seems to be the right thing," Orv argued. "As the machine turns the tail will be set more and more against the wind, and that will naturally tend to swing the whole thing back again.

"It can't be that fixed fin, though. We've proved that. Why can't we make it a movable fin—a kind of rudder?"

They tried it, and it seemed to be satisfactory. For, when the machine turned to the left, pulled around by the warping of the wing, a counteracting motion of the rudder swung the whole glider back on its course.

"It works," reported Orv after a trial. "But it's a strenuous job, lying there and working ele-

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vator planes, wings and rudder, all at the same time."

"What's more," reasoned Wil, slowly, "our theory is that the wings and the rudder work together, isn't it? Well, let's ——"

He stopped, and they both turned to look at the long white wings with their intricate mesh of struts and wires and guys and supports. Their eyes traveled together to the control wires leading from that new movable tail to the side of the pilot's position. It was within easy reach of the second of the three control wires—that coming from the wings.

"All right!" Orv grinned. "Let's!"

They got to work, and when the machine next took off from the sandy hilltop it had a new theory incorporated in it. The tail and the wings were controlled by the *same* handle; when the wings were warped the tail was turned automatically to counteract the turning effect.

"We've got it!" exulted the Wrights.

All in all, that 1902 glider—the one built wholly on Wright calculations—made a thousand flights. It flew as safely in a wind of thirty-six miles an hour as it did in a mere breeze of fourteen. It stayed in the air for half-minutes at a time; it

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nearly doubled the former distance record, for it made a flight of 622 feet.

It was after one of these—at that time—miraculous flights that one of the unscientific assistants of the Wrights, marveling at the success of the cloth-covered bird, made a suggestion.

“Far ’s I c’n see,” he declared, solemnly, “the only diff’rence ’tween your machine an’ a sea gull is, a sea gull has feathers on his wings. Now, ef you’d jest put feathers on this yere contraption, ’stead o’ muslin—why, she’d never come down!”

Octave Chanute and Dr. Spratt were again interested observers at the Kitty Hawk camp, and their approval of the things the Wrights were doing was complete. Not only had Wil and Orv outdone Dr. Spratt, the technician, in scientific experiment to establish what were truly the laws of air pressure; they had also gone far beyond the work Chanute had spent years in doing, and their 1902 glider outperformed anything he had built or dreamed.

When camp was struck at the end of October the preliminary work in preparation for the construction of a power plane was practically finished. The two bicycle-makers from Dayton,

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quietly and without ostentation, had reached the point which other men with college training, extensive financial support, and eager governmental encouragement had hardly envisioned. They were on solid ground; they were sure of their footing. When Wil and Orv Wright, that October day, looked at each other, they agreed they were ready to do the thing they had never dreamed of as short a time as three years ago.

It is important to remember that these two silent men whose study was the family "sitting room" and whose laboratory was the work-bench in a small Middle West bicycle shop, were the most complete scientists in methods of thinking and working. They first had studied everything there was to study—not only reading English, but often struggling through the more extensive German and French literature on their subject; they had combed through theories and statistics and experimental notes and discarded most of what they found. They had kept the small amount of usable material—material brought to light in four years of digging—and had gone to work with it. They never made an experiment in the air until it was as certainly a success as all this hand-picked theory could make it.

And the greater wonder is that, with all the

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misleading "facts" their study gave them, they still evolved sound ideas of aviation and aërial equilibrium. Wil and Orv Wright had established themselves, by the end of their 1902 gliding, as scientists ranking with the greatest in the world's history.

CHAPTER XXI

LANGLEY'S BUZZARD

PUBLIC opinion, in 1902, would have considered the Wright brothers anything but scientists. The thing that saved them from widespread ridicule, probably, was the fact that only a few knew of their experiments and their growing ambitions. Many of those few who did know thought them "nuts."

"If man had been intended to fly," said more than one pious critic, "why wasn't he provided with wings?"

And an eminent scientist, Dr. Simon Newcomb, wrote an article which appeared in a 1901 *McClure's Magazine* in which he asserted conclusively that early twentieth century hopes for heavier-than-air flying could be no more than idle dreams.

"I have shown," he wrote, "that the construction of an aerial vehicle which would carry even a single man from place to place at pleasure requires the discovery of some new metal or some new force."

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Dr. Newcomb had taken the scientific attitude of impartial investigation in his article; but he was unequivocal in his decision that aviation was too far in the future, too difficult under existing conditions, to be worth serious consideration.

His conclusion was completely in accord with the popular feeling toward flying. Indeed, thousands of men and women in 1901 and 1902 looked with deepest distrust on the newest device of the devil, the horseless carriage—the new-fangled automobile that was then wheezing and chugging its way into the cities of the nation.

Meanwhile another man, Professor Samuel P. Langley, was continuing his experiments in this “crazy” new science. Professor Langley was a man at whose scientific attainments no critic dared sneer. He worked in collaboration with the Smithsonian Institution, and his record as a scientist was nationally known. In 1896 he had caused a model airplane with a small steam motor to fly, and those who knew of his work felt that, if anybody could accomplish the impossible, Langley was the man.

Professor Langley wanted to stop his labors in the field of *aéronautics* with the flights of that model plane, it has been said since. He was then sixty-two years old; he believed that he had

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demonstrated that mechanical flight was possible, and he wished to devote his time to other work. But the United States War Department had taken interest in his experiments, and persuaded him and his assistant, Charles M. Manly, to continue with the construction of a machine capable of carrying a man as their aim. To this end the government granted Professor Langley a subsidy of \$50,000.

For years Professor Langley and Mr. Manly worked on the machine, which was to be a full-size replica of the fifteen-foot model. They faced, during their experiments, the attitude which Dr. Newcomb's magazine article exemplified. Nevertheless, through all the years during which the Wrights were studying and making their gliding flights, they continued. At length, in the autumn of 1903, they were ready to attempt to fly.

On October 7th the first trial of the completed "aërodrome" took place at Widewater, Virginia, a point thirty miles below Washington on the Potomac River where the stream widens to form a four-mile lake. Here Professor Langley had constructed a "huge, ark-like houseboat, on top of which, for its full seventy-foot length, a two-railed track was laid. At one end of the track, backed snugly against coiled steel springs, was

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what Langley called a 'catapult car,' the object of which was to hurl the airplane into the air at navigating speed."

The *Washington Post* described what happened that day when at last the trial was made:

"At noon it was realized that the crucial moment was at hand. Shortly after twelve o'clock Mr. Manly, wearing a pair of light trousers, canvas shoes, a life preserver, and a pair of automobile glasses, climbed into the car. Two tugs, each with a portion of the Smithsonian force aboard, were stationed out in the river at a distance from the ark. When all was ready Mr. Manly nodded his head to a helper, who fired a skyrocket warning to photographers on the Virginia beach to be on the *qui vive*.

"A few yards from the houseboat were the boats of the reporters, who waved their hands to Mr. Manly and wished him good luck. He looked down and smiled. The propeller wheels, a foot from his head, whirled around him a thousand times a minute. A man on the forward part of the superstructure fired two skyrockets into the air. There

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came an answering 'toot, toot' from the tugs.

"A mechanic stooped, cut the cable holding the catapult in leash; there was a roaring, grinding noise and the Langley airship tumbled over the edge of the houseboat and disappeared into the river, sixty feet below. It simply slid into the water like a handful of mortar."

The wiseacres smiled discreetly. The newspapers declared, "I told you so," in half-derisive stories and editorials. Professor Langley and Mr. Manley pulled their machine out of the river, patched it, and, on December 8th, essayed another flight. Said the *Washington Post*:

". . . When the airship was launched, just below the city, the rest of the Smithsonian staff, the stuffers of birds and rabbits, who have nothing to do with airships, climbed to the top of the Smithsonian tower with telescopes and field-glasses and watched.

"It gave no promise of flight-sustaining powers, but tumbled straight into the river as if the propellers and the wings had not been working."

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Comments, now, were unveiled in their satire and sarcasm. "AERODROME DID A FLOP," reported one newspaper heading; "DUCKS PROF. MANLY," chortled another. And an observer wrote:

"The buzzard flew exactly as far as its initial impetus compelled it to fly and not a hair's breadth farther. With the exhaustion of that impetus it fell into the water with all the rude directness of an unsupported brickbat. Any stout boy of fifteen toughening winters could have skimmed an oyster shell much farther, and that without months of expensive preparation or any of the august accessories of government fleets, appliances, and retinues. The buzzard is a didapper and that is all there is about it."

Professor Langley, scientifically, was no less confident after these two accidents than before. He was positive that mechanical flight was a possibility, and he felt that this machine of his, with certain adjustments, was capable of flying. But the accidents ended his experiments. Those who knew him declared that the ridicule to which he was subjected caused him to give up his work.

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The whole world, it seemed, was ready to jeer. Ambrose Bierce, a talented fiction writer, declared:

“I don’t know how much larger Professor Langley’s machine is than its flying model was—about large enough, I think, to require an atmosphere a little denser than the intelligence of one scientist and not quite so dense as two.”

Two years later Professor Langley died—“laughed to death.” His wrecked machine, again repaired, was given to the Smithsonian Institution as an exhibit.

And the nation’s derisive confidence that flight was a pipe dream was strengthened.

CHAPTER XXII

WINGS THAT FLY IN A CIRCLE

NEARLY a year before those two disastrous attempts at flight by the Langley aërodrome, and just twenty-nine months after the first successful gliding flights Wilbur and Orville Wright had made, the brothers applied in Washington for patents on various of their inventions. The new principle for maintenance of equilibrium—the connection and simultaneous operation of the rear vertical rudder and the movable wing corners—was the most important of the new ideas their application, made March 23, 1903, brought to light.

But for three months before that Wil and Orv had been working on plans for a power flying machine—one that would lift itself by its boot straps into the air, fly regardless of wind, and descend where they wanted it to. The machine itself—the actual wings and rudders—furnished no problem.

“That last glider came down only because there wasn’t enough wind power to hold it up,” said

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Orv. "That means that, if we supply the power, it ought to stay up indefinitely. So we don't need to change the design of the machine in any important detail. Just make the new machine enough larger to carry a heavier load ——"

But there were two new problems. One was the motor; the other was the propeller.

"We don't know much about motors," pondered Wil. "Only one we've built is that little air-cooled fellow we use to run the machinery in our shop. And it's made with a five-inch bore and seven-inch stroke; that won't do at all for an air-plane motor."

"Not by a long shot. Maybe, though, one of the automobile manufacturers can build us what we want."

"Right," agreed Wilbur. "Let's find out exactly what we do want, then ask 'em."

They applied their tables of air pressure and lift to the machine they had designed, and discovered that, if the motor generated eight horsepower, the plane should lift a total of 550 to 600 pounds. The motorless plane would weigh about 250 pounds; the operator would weigh 140.

"Can you build a motor that will deliver eight horsepower and weigh 200 pounds?" they wrote to half a dozen automobile makers. Then, while

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they were waiting for replies, they started to work on the second problem—the propeller.

A propeller is simply “a wing traveling in a spiral course.”

That was the theory with which the brothers started. On that they could agree. But, as they dug into the knotty problem—and found it daily knottier—their arguments grew frequent and violent.

“The best way to find out about propellers,” Wil would say, “is to read what marine engineers can tell us of the action of a propeller blade in water.”

And likely as not Orv would eye him with amazement.

“In water! What’s that got to do with its action in air?”

Then would come one of those long discussions that commenced at a bicycle-shop work-bench, lasted through lunch hour and an afternoon, continued as the brothers went home in the evening, and was not terminated when, near midnight, they went to bed—long after Bishop Wright and their sister had thrown up their hands and retired. And the upshot was, as had happened before, that each brother had been convinced by the other and was arguing on the other side of

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the case; for that happened more than once during the parlous days when the propeller was under discussion.

But even those arguments were fruitful. For they brought out every point that might bear on the question, and they usually resulted in a decision as to the best way to settle the problem.

They sought out what there was in books about propellers, and found nothing. Marine engineers knew little about the action of a screw in water. Their propellers had been made on empirical formulæ, and what really happened in transfer of power, loss of energy, thrust, and the like was obscure. Although marine screws had been in use for a century, knowledge of them was only theoretical—little more advanced than when the first one was put into water.

“We’ll have to disregard what’s been done and go ahead on our own,” decided Wil.

Probably that started another discussion. For the brothers did not feel that they could embark on a long series of experiments to discover what propellers did in the air. They had not the time nor the finances. So at length they decided to find out everything they could from study of available statistics and charts and tables, and then to build their own propellers.

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What at first seemed a complex problem became a tangled labyrinth of forces and thrusts and pitch and air currents as Wil and Orv dug into it. "With the machine moving forward, the air flying backward, the propellers turning sidewise and nothing standing still, it seemed impossible to find a starting point from which to trace the various simultaneous reactions," Wil complained. "The very contemplation of it all set our heads to whirling as we wanted our propellers to do!"

Months passed, and still a maze of facts and theories veiled the solution. Then, slowly, those daily arguments at work and in the little frame house started to lift the befogging curtain. Various reactions began to untangle themselves. The brothers, using reams of paper and the most abstruse mathematics, gradually discarded a propeller of this kind or that; decided that two blades were better suited to their purpose than four; selected the exact pitch, or angle, of blade they wanted; settled on length and necessary speed.

Their own tables of lift and pressure, again, proved to be the key to the problem. By use of these tables they figured that, just as there was no "best" kind of wing—a certain wing might be best suited to one use but not at all to another—

there could be no "best" propeller, no propeller that answered every purpose best.

"The thing is," puzzled Orv, "that a propeller that'll do the best climbing isn't at all the one that'll give the most speed. One that will pull this plane the way we want it pulled might not work at all on somebody's else machine. So what we have to do is figure out just which one will suit *our* needs best—then build it."

For weeks, then, the bicycle workshop looked like a planing mill. Everywhere were shavings—ringlets and splinters of wood off the blocks which Wil and Orv cut down to suit the design they decided, theoretically, was what they wanted. For they had selected a particular pitch and diameter and width—just as, using theory, they had successfully worked out the correct proportions for the 1902 glider—and they thought it would do what they wanted done.

Then came the day when they hitched a finished propeller to a motor and started it to work. Due to their experiments of the previous year, it was no problem for them to measure the results—the speed of air current and the horsepower it delivered. And they discovered that, in their first screw, they had a machine one-third more efficient than any developed by Sir Hiram Maxim or

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Professor Langley. It delivered sixty-six per cent of the power the motor expended in turning it—delivered it in “useful work” or usable air current.

That meant that with a motor developing eight horsepower they could expect to get more than five horsepower from a propeller driven by it. Langley could have got no more than four from the same motor with his propeller.

So the problem of the “wings traveling in a circle” was solved.

For two reasons Wil and Orv decided to use two propellers, one on either side of the pilot just at the rear of the wings. One was that two propellers would be more effective than one.

“We’ll get a reaction against a larger wind current—two will create more ‘wind’ than one,” explained Orv. “We can use a larger pitch in our propellers, too, than we could with only one.

“The second reason is that we can have them turn in opposite directions, and thus neutralize the tendency of powerfully whirling pieces of machinery like the ‘prop’ to twist the plane around sideways, in the direction opposite to that in which they’re going.”

Thus they had anticipated and avoided a problem which might have caused serious trouble in

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those early days of aviation. In later years, when airplanes were developed to a higher degree of efficiency, student aviators were early taught to keep the rudder of a plane turned just the tiniest bit to offset the tendency of the single propeller to turn the whole machine. It is possible that any amount of "right rudder" might not have kept that first Wright plane upright, had it had but one screw.

The propellers were to be placed back of the wings so that the wind was drawn past them, rather than in front so as to thrust it past. A number of early planes made by imitators of the Wrights used this "pusher" plan; but later aviation decided that the so-called "tractor" type was more generally useful.

CHAPTER XXIII

MAKING A MOTOR

LONG before the propeller problem was settled a new difficulty arose. Nobody could be found to furnish a motor.

The letters to automobile manufacturers had been fruitless. Most of the companies answered promptly that they were too busy with their regular business to undertake the problem of building one small motor on special designs. Only one manufacturer replied hopefully:

"We have a small motor rated at eight horsepower (according to the French system of ratings) which weighs only 135 pounds. If you think this will give your machine the power it needs, we shall be glad to sell you one."

The manufacturer sent specifications for the motor with his letter—it was a one-cylinder machine of four-inch bore and five-inch stroke. It did not take the Wrights long to decide that eight horsepower "according to the French system of ratings" would be far below the eight horsepower they needed.

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So here was another obstacle to climb over. They pondered it for a while.

"You remember," said Wilbur one day, "that when we needed a brazer, back in the early days of our bicycle business, and couldn't afford to buy exactly what we wanted, we made it?"

Orv looked sober. "Yes, and lathes and dozens of other tools," he replied. "But an airplane motor—that's a different proposition, isn't it?"

"Nobody knows as well as we do exactly what we need. Let's give it a try, anyway."

They were enthusiastically seconded by C. E. Taylor, who did the machine work in the bicycle shop, in their attempts to make a motor. For five weeks, the three of them prepared cylinders, seated valves, tested sparks in the rough ignition system, machined pistons; and by that time the work had progressed far enough that they began to think about trying it out. Would it develop the eight horsepower they wanted, or would it turn out to be a dud?

"Seems to me," said Taylor one day, "that it'd be too bad to spend a lot of money putting the cylinders and all into an expensive frame and then find they didn't work. Why not put 'em in something temporary and find out how they perform?"

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A week later the four cylinders were mounted in a cheap temporary frame, one that did little more than hold them firm and form a base for the test of their power. There was no lubrication, either of cylinders or bearings, so the three did not dare run the motor more than a minute or two at a time.

But it did run. In the several brief tests to which it was subjected it delivered nine horsepower—more than the builders had hoped.

“And that’s without lubrication or permanent mounting or any of the refinements we can give it,” Wil declared jubilantly. “When it’s properly finished it ought to develop at least twelve horsepower. And that’ll mean—let’s see.”

In an instant he turned from the piece of paper he had seized.

“It’ll mean that we can add a hundred and fifty pounds to the machine if we want to!”

So the weight limit was set at 750 pounds instead of 600—a limit that permitted Wil and Orv to include in the design a good deal of strengthening and certain enlargements they had desired but considered impossible, and still to leave a greater power margin than they had thought the safety minimum.

A few weeks later the final test of the motor

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was made. To the amazement of Taylor as well as of his employers, the little machine, once started, "turned up" sixteen horsepower for a few seconds. At the end of a minute this dwindled to twelve, but the motor continued to furnish this twelve indefinitely. The Wrights were exultant.

"Twelve horsepower from a little four-cylinder motor!" they marveled. "Incredible!"

When they learned, in later years, that four-cylinder motors somewhat like theirs could be made to furnish more than double those twelve horsepower, they realized how crude, in many respects, it must have been.

It had been decided to set the motor in the machine alongside the pilot's position—the pilot was to lie prone on the lower wing, as in the gliders—so that, in case of a plunge head first, it would not fall on him. They believed he would be safe from injury in other falls.

"In our gliding experiments we had had a number of experiences in which we had landed on one wing," Orville explained, "but the crushing of a section of the wing or wing-tip had absorbed the shock. So we were not uneasy about the motor in case of a landing of that kind."

The plane, however, was not to be built until after the brothers had arrived at Kitty Hawk.

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This meant that there would be no opportunity to try the motor and the chain drive for the propellers until after the plane was constructed, unless they should set motor and screws up in a temporary block in their bicycle shop in Dayton. This they decided to do.

The device for driving propellers in opposite directions was simple enough. A heavy tubular shaft took the power from the motor and transmitted it direct to two large sprockets. On these sprockets were fitted chains, much like the bicycle chains Wil and Orv had worked with so much, and one chain ran to a similar sprocket on each propeller. But, in order to reverse direction of one of the screws, one chain was twisted—crossed in the middle so that it formed an elongated figure eight—and fitted onto its propeller sprocket so that it transmitted power in a direction just opposite to that of the other propeller.

Trial of motor and propellers at once developed a new weakness. The propeller shafts had been designed of heavy-gauge steel tubing, tested and proved completely strong enough to transmit the amount of power given them by the motor.

But a steel tube has not the resilience, the flexibility, of a solid steel rod. And these tubes, three or four times as strong as statistics seemed to

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require—had the power applied to them flowed easily and smoothly, as in an electric current—would not stand the continual shocks of gasoline-motor explosions. Sometimes an explosion might be premature, sometimes late, sometimes missing altogether; and the result was that a continually changing force was being applied to the propeller shafts.

Signs of weakness appeared in them. There was only one thing to do—supply new ones of greater strength. So, just before Wil and Orv were ready to leave for North Carolina again, this last change was made.

Then, so they thought, they were ready for the great adventure.

"Within a month," Wil told Bishop Wright, smiling at them (though perhaps with a tear in his eye) as they departed, "we ought to have good news to send you."

"I think you will," returned the white-haired man. "And I don't want to wait for a letter." Here—his hand went into his pocket—"here is a dollar. Be sure to wire to me when you get into the air!"

There was no doubt in this still rugged old man's mind—he was seventy-five years old now—that his sons would succeed. Nor in the mind

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of his daughter Katharine. And Wil and Orv were confident, as well, for they gave up their bicycle shop when they left it that autumn.

"We're aëronauts now," grinned Orv, half seriously. "Everything we have is going into this piece of machinery. It's simply *got* to fly!"

CHAPTER XXIV

GETTING READY

IT WAS September 23, 1903, that Wilbur and Orville Wright left Dayton for Kitty Hawk. They arrived at their camp two days later, and found waiting there provisions and tools which had been shipped from Dayton several weeks previous.

But they found waiting something else—something in the nature of an unpleasant surprise.

“What’s happened to our shed?” grunted Orv, in amazement, as they reached the Kill Devil Hill district. “Did we set it askew like that?”

There certainly was something wrong. The yellow sand hills were unchanged—they glittered in the Carolina sunlight as always—and the light breeze the brothers had come to expect was blowing. Off to the east, from the higher points, could be seen the calm blue of the Atlantic. Here was the slope from which the 1900 glider had made its first hop. Yes, the setting was right.

But the shed, built in 1901 and enlarged in 1902 to hold the improved glider—that shed was

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decidedly wrong. It sagged drunkenly, and its corners seemed to be twisted entirely out of position. It still held together, still sheltered the successful glider the brothers had intrusted to it, but some giant hand had moved it, and not too gently. Closer examination showed that it was completely off the foundation posts on which it had been laid.

Old-timers—members of the near-by Kill Devil Hill life-saving station crew, now trusted friends and assistants to the experimenters—scratched their heads.

“Back there in the spring,” said one, “there was an almighty powerful wind storm. Pretty near blew the tops off these hills here. Reckon that was what did it?”

That seemed to be the answer. At any rate, it had to suffice; the Wrights weren't particularly interested in what had done it, anyway. There was work to do: a plane to build, the shed to repair. Fortunately, the glider in the shed had been little damaged. It was decided to erect a new building near the old one, to serve both as workshop and as assembly-room and hangar for the new machine.

There was plenty of time for this. Parts of the new airplane, materials for it and the motor and other essentials to the flight they hoped to

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make, had not yet arrived; they had been shipped from Dayton at the time Wil and Orv had departed. So, while they waited, the two went ahead with the construction work. The new shed was a large frame structure, made with hinged doors as the first one had been; its roof was covered with tar paper.

It was just as the building was completed that the parts and materials from Dayton arrived. Coincident with the parts and materials came one of the worst storms Kitty Hawk had experienced in years. It arrived with a keen cold blast that sent the brothers scurrying for shelter, and their anemometer showed that even its first gusts were blowing from thirty to forty miles an hour.

"Now it'll have two buildings to play with, instead of one," worried Orv.

"What I'm thinking about," returned the older brother, "is that new tar-paper roof. Did we put enough nails in it to hold it?"

They decided that, if the speed of the gale did not go above forty or fifty miles an hour, their roof would be safe. But during the night the gale became a hurricane, and shrieked and tore at the eaves of the building like a raging wildcat. In the morning its speed was seventy-five miles an hour,

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and Wil and Orv had visions of their roof sailing off into space as no plane had ever sailed.

"Nail it down!" decided Wil, suddenly. "That's what we have to do!"

So, with ladder, hammer, and roofing nails, they went out into the roaring, ripping wind and fought their way—literally fought it, step by step, for making headway against a seventy-five mile hurricane is no parlor pastime—to the most exposed side of the building. Somehow they raised the ladder and leaned it against the eaves.

"I'll go up!" shrieked Orv. "You hold it!"

Wil looked at him uncomprehendingly. "What?" he shouted. His brother's ear was two feet away.

"I'll climb up ——" commenced Orv again. But he saw that attempts to converse in that thundering storm were futile. He resorted to sign language.

This time Will understood, and slowly Orv worked his way up the rungs of the ladder. He was barely at the edge of the roof, in position to commence his work, when suddenly he was gripped from the rear by a fist of iron, something that seized his arms and whole body and held him close against the ladder, as helpless as though he were in a strait-jacket!

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At first he did not know what it was. Then he realized that the wind had taken his long overcoat and whipped its flying tails up around him, imprisoning him in bonds he was powerless to break. He couldn't even call to Wil, at the bottom of the ladder!

But Wil saw his predicament, and slowly he mounted the ladder. In a second's lull of the gale he was able to seize his brother's coat and pull it down; there he held it while Orv set painfully to work.

The work was not overly successful. "The wind was so strong I couldn't guide the hammer. I hit my fingers as often as I did the nails," grumbled Orv, a few moments later, when they plunged into the building again and tugged the door shut after them.

But the roof stayed on, and that was what mattered!

Three weeks were spent, after that, in getting the machine together. This work carried the brothers into November, for they had not been able to commence assembly until about October 15th. Meantime their two visitors of previous years—Octave Chanute and Dr. Spratt—arrived on the ground, hoping to watch the first attempt at power flight. As it happened, neither saw the

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first attempt, for difficulties so delayed the new machine's trial that both men had to depart before it occurred.

They watched renewed glides in the 1902 machine, however. For, when the wind was suitable, Wil and Orv frequently took the plane from its shed and launched it from the top of Kill Devil Hill. Its flights this fall surpassed anything it had done before. Glides of more than a minute occurred often; it soared and rose and settled seemingly at will.

Now, as they were turning to something entirely different, the Wright brothers most nearly approached the goal they had originally set for themselves—free flight in a motorless plane, wind-soaring as a sport.

But their hands—and minds—were too full to permit them to spend any but spare time on this. Chanute brought up a new worry as he examined the motor they had built, and went over its connection to the propellers.

"How much have you allowed for loss of power in transmission?" he queried.

"Not much—about five per cent," was the reply.

"That's bad!" Chanute declared, flatly. "Engineers always count on a twenty-per-cent loss!"

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That was a blow that worried the brothers for days. If the power they gave to the propellers was decreased that much, all their figuring might be off. The five-per-cent figure they had reached by a crude measurement of the friction between one of the chains and its sprocket when the chain was carrying a very light load.

"If Mr. Chanute's right," Orv pondered, "more than the entire surplus of power we've allowed will be used up in friction!"

Anxiously, after Chanute left for Chicago, they made a more careful test. They took one of the chains and hung it over a sprocket, with both ends loose. On each end they hung sand bags whose weight was equal to the pull that would be exerted on the chain when it was actually driving the prop. Then they slowly added extra weight to one side; and at first the equilibrium was maintained.

But at length the heavier side slowly sank, pulling up the weight at the other end of the chain. And the two men knew that, if their figuring were right, the extra weight on one side should be a measure of the friction loss in the sprocket.

It was a relief to them to discover that the added weight corresponded almost entirely to the

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first figure they had reached—five per cent of the total.

“There should be no serious error in finding the amount of loss in this kind of test,” Orville noted. “Just the same, I won’t feel comfortable until we have a chance to run the propellers with the motor and to learn definitely whether we get as many turns a minute as we expect.”

CHAPTER XXV

TESTS AND DELAYS

ON NOVEMBER 6th the machine looked ready to fly. The wings were constructed, the elevator and tail attached, the motor was installed and linked to the pair of propellers. It was another of those nervous moments to which the Wrights had become inured. So many disappointments had been their lot, so many things had gone wrong at one time or another, that they were more than able to take misfortune with a grin.

Still, there was the eternal hope that this time everything was just right. If the motor and propeller should stand this first test, in a day or so actual flight ——

And the very first test developed a flaw in one of those doubly strong propeller shafts—a flaw that had evaded notice, somehow, in the Dayton tests.

There was nothing to do but send it back to Dayton for repair. Facilities for putting it into shape, and the man who could do it understand-

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ingly, C. E. Taylor, who had done so good a job on the motor, were there; so Wil and Orv did not consider finding a local workshop to handle the task. Even if they had, it is doubtful that the combined resources of Manteo, Kitty Hawk, Nag's Head, and every other near-by village could have furnished the necessary apparatus.

So back to Dayton both of the shafts went. For two weeks the brothers idled time (restless weeks they must have been) with gliding flights and test after test, with discussion and repeated planning for the first power flight. On November 20th the shafts came back, sound and shiny.

Before the day was half along they had been installed in the machine and tests of motor and propeller commenced anew.

And a new trouble developed!

The sprockets had been screwed on the shafts—main and propeller shafts—and locked in place with nuts of opposite thread. Theoretically they should have been held firmly in place. But in practice the jar and shake of the motor persisted in twisting them loose. Time and again Wil and Orv applied wrench and muscle, sweated and tugged and wondered.

Nothing they could do, seemingly, was enough. Tighten up, start the motor—loose sprockets

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When evening came the brothers were as badly discouraged as they had been in a long time. They had conquered far knottier problems than this; but this seemed to have them floored.

"It's as simple as driving a nail," grumbled Wil.

"Yes," replied Orv, "in a seventy-five mile gale!"

They fell into bed with the solution still hidden. It was next morning, when the sun came up out of the Atlantic, that things seemed to brighten. Orv had an idea.

"Tire cement," he declared, "will do almost anything."

Wil eyed him curiously.

"We know how well it worked," the younger brother went on, "when we used it to hold tires and rims together. And there was the time we repaired that stop-watch with it. Maybe tire cement will make this airplane run!"

There was nothing to be lost by trying.

The pot of tire cement—brought along for any of a dozen miscellaneous uses—was brought out. Shafts and sprockets alike were heated. Tire cement was spread in the threads and melted there, so that it would be as liquid as they could

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make it. Then the sprockets were screwed fast to the shafts, and the cement given time to harden.

The trouble was over. The sprockets withstood every shock and held fast in position.

At last, then, the machine seemed ready for its initial trial. Motor ran perfectly, sprockets held fast, shafts seemed to stand the strains they received. The propeller delivered a satisfactory wind power.

"No reason why we shouldn't fly tomorrow!" declared Wil soon after the tire cement had repaired the last difficulty.

But the weather man took a hand and supplied plenty of reason. For some time—practically ever since that hurricane in October—the weather had been so cold that it had been almost impossible to do careful work on the machine out of doors. Now conditions became worse. The wind, always keen at that time of year, switched into the north and changed rain into snow. For several days it blew as though it came direct from Hudson Bay, at a rate of twenty-five to thirty miles an hour—far too great, the Wrights, ever cautious, thought, to permit them to try their untried craft.

They got busy on a new device—a little machine that was to be one of the first airplane in-

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struments in existence. It consisted of a stop-watch, an anemometer, and an automatic counting machine; all started automatically when the machine should start in motion and stopped when it stopped.

Thus, the brothers figured, they could provide themselves with definite knowledge of the length of time the machine remained in the air (the stop-watch would tell them that); the speed of the wind supporting it (the anemometer measured the wind traveled through); and the number of revolutions made by the propellers. With a knowledge of exact time in the air and of the ground traveled over—this information to be gained by measurement—they could easily discover the speed of the plane.

And the data this combination instrument would give them should be inestimably valuable in determining laws of flight with regard to power planes—something about which nobody in the world had ever had reliable information.

For a week, while the weather continued wretched, Wil and Orv worked on the new device and on a hundred minor changes and adjustments. On November 28th they were trying the motor in an indoor test.

“Seems to me,” said Wil, suddenly, “that

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there's something wrong with one of the propeller shafts!"

It was a discouraging suggestion. Twice they had removed and remodeled and repaired shafts that apparently had been more than strong enough. But the motor was stopped, and Wil proved to be right. One of the tubular shafts had again given way before the jar of the motor, and it showed a diminutive crack.

This time they did not waste time figuring or wondering.

"That proves it," declared Orv. "A tubular shaft simply hasn't enough spring in it to absorb unequal strains, no matter how strong it may be. We'll do best to give them up entirely and to substitute something that'll work satisfactorily."

"Solid tool steel," Wil said. "That'll do it. Tool steel of smaller diameter than the tubular shafts. They'll allow a certain amount of spring—more than these things—and they'll carry the load as well."

"We better send to Dayton in a hurry for them," his brother added. "We haven't time to lose. Maybe one of us better go after 'em."

Thus it was decided. Wilbur remained at Kitty Hawk, while Orville entrained for Dayton. There he plunged into work at the bicycle shop,

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and, with Taylor's ever-efficient aid, turned out the new set of shafts. They responded satisfactorily to every test to which he subjected them.

"They ought to do!"

Then he was on his way back to Kitty Hawk. It was Friday, December 11th, when he arrived there.

CHAPTER XXVI

WIL WINS A TOSS

IN NOVEMBER, when the machine might have been ready to fly, the weather had been too severe. Now, on Saturday afternoon, when the new tool-steel shafts had been cemented and screwed into place, the weather was too mild!

"There isn't enough wind to take her off the ground," Wil muttered, disgustedly. "Nor enough time, before dark, to carry her up one of the sand hills!"

In later days of aviation, when methods of take-off had been improved, the lack of wind would have been no obstacle. But the Wright method demanded exactly the right conditions.

This method called for the use of a monorail track—a track Wil and Orv had built during one of those waiting periods. Sixty feet long, the track was so constructed that it could easily be moved from one place to another; it was adapted to use either on a hill or on level ground. And Wil and Orv planned that their machine should be in the air before it reached the end of the track

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—a feat that seems almost incredible in days when a big transatlantic plane sometimes needs three thousand feet to “pick up” flying speed.

Because they had decided on the track take-off, Wil and Orv had come to the conclusion that wheels for a landing would be an unnecessary weight and obstruction. In their place they had built a light, but very firm, framework, something like sled runners. These extended out to the front of the main planes, and later were lengthened to form one of the sets of supports for the elevator planes. The extension ahead of the wings was intended to obviate the possibility of rolling over forward in landing.

On that Saturday afternoon the wind remained mild. Sunday was a beautiful day—one on which an attempt from the hillside might have been made. But the Wrights, always true to their home training, believed that Sunday was a day of rest and refused to use it otherwise. So, eager as they were to reach what was to be the peak of their experiments, they allowed the machine to remain idle through a calm, windless Sunday.

Monday was the same kind of day. There was not enough wind for a start from the level ground.

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"It'll have to be from one of the hills," declared one of the brothers.

"Yes," assented the other. "Let's get the track up on the side of Kill Devil."

So the first attempt at power flight was made from the same slope on which the first undulating, jerky glide had been made, just three years before. Before Wil and Orv started to move the machine over, however, they ran up the little flag which they had agreed to show, so that members of the life-saving crew, at their Kill Devil Hill station a little more than a mile away, might know they intended to try a test. Soon five members of the crew—J. T. Daniels, Robert Wescott, Thomas Beachem, W. S. Dough, and "Uncle Benny" O'Neal—were on hand, helping to carry machine and track to the starting-point.

The wooden monorail track was laid a hundred and fifty feet up the side of the hill, on a nine-degree slope—a slope of about one foot in six. With the incline of the hill, the thrust of the propellers, and the light wind directly ahead of the plane, the brothers believed there should be no difficulty in getting into the air.

"But there may be difficulty," Wil warned, "in keeping the machine balanced on that track before she takes the air. The fellow who isn't fly-

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ing can help by running alongside the wing, holding it level as long as he can keep up with it."

Finally everything was ready. The machine, an orderly maze of wires and struts, braces and guys, vertical supports and horizontal arms, stood poised on the track, held in place by a wire. The motor had been tested and found to be in perfect condition. The wind remained mild.

Wil and Orv looked at each other, eyes twinkling a little. Who was to fly it first? Each was eager to have a trial at it, far more for the fun of seeing how it would work than for the "honor." For these patient, steady men had little thought of glory. If they had had, they would not have been working in so obscure a place as the North Carolina dunes; they would not have allowed their experiments to go so completely unnoticed (although they had never made attempts to avoid notice); and they would certainly have given more thought to the circumstances surrounding that first attempt. Not a newspaperman had been notified of it.

And up to that moment they hadn't even considered the matter of the machine's pilot!

"Let's flip a coin."

They did. Wilbur won.

Flying, in 1903, did not mean specially con-

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structed helmet, leather coat, parachute, and goggles. Wilbur Wright, in cloth cap and his working clothes, climbed onto the lower wing of the plane. The pilot was to lie prone, as in the gliders. A kind of "cradle" fitted his hips; by its movement he manipulated the flexible wings and the rudder. In one hand he gripped the elevator lever. The motor clattered and roared. Everything was ready.

Wilbur released the catch by which the restraining wire was held, and with a rush the machine darted forward.

It moved so rapidly, what with the slope of the hill and the power of the two propellers, that Orv, running beside the wing, was left behind in an instant. Forty feet down the track it lifted, and the hearts of the brothers lifted with it. There was a faint cheer from the life-savers.

But the cheer changed to a gasp as the machine took a lunge. Wilbur, over-anxious, had nosed it too steeply into the air. It climbed for an instant; then it stalled—much as the gliders had stalled when they climbed and lost flying speed—and Wil had to make use of the flying lesson the gliders had taught him. He reversed the elevators and the machine swept down the hillside, settling to the ground 105 feet below the take-off.

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Orv snapped the stop-watch he held in his hand; it showed a "flight" of three and a half seconds!

The landing was disastrous. The left wing swung down too late for Wil to regain balance by use of the rudder and wing-warping, and scraped along the ground. The machine swung around, dug the skids into the sand and broke one of them. Other minor parts of the framework were broken. Flying was ended for that day.

But it took more than that to discourage Wil and Orv Wright.

"While the test showed nothing as to whether the power of the motor was sufficient to keep the machine up, since the landing was made many feet below the starting-point," Orv explained later, "we have demonstrated that the method we'd worked out for getting the plane into the air was safe and practical. On the whole, we were much pleased!"

CHAPTER XXVII

ORV'S TURN

LATE in the afternoon of December 16th, two days later, the skid and other damaged parts were repaired and final adjustments were being made. The machine was standing on the track in front of the shed which had been built for it, and Wilbur and Orville, by themselves, were working over it. A stranger, a man who had never seen the curious craft before, came past. Silently he surveyed the machine from this side and that. At length he spoke:

"What kind o' contraption you makin'?"

One of the brothers looked up. Wil and Orv were always glad to answer questions.

"It's a flying-machine—an airplane."

The man squinted his eyes. It was a new kind of bird to him.

"You mean it goes up in the air? You ain't really goin' to fly in it?"

"Just what we think we're going to do," laughed the other, "if we get a suitable wind tomorrow."

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The stranger stared. He stroked his chin, swept his glance over the maze of wing and wire, and gulped.

"Wal," he commenced, "looks to me 's if she oughta fly, er somethin'—if she gits a—a suitable wind!"

Then, shaking his head, he went on. And Wi and Orv stopped work to chuckle.

"When he said 'suitable wind' he was thinking of that seventy-mile breeze!" grinned Orv. "That kind of wind would make anything fly!"

The wind that rose during that night was not as "suitable" as might have been desired. It came down from the north, and the below-freezing temperature it brought with it formed shells of ice on the dozens of little puddles standing in hollows about the camp, the result of recent rains. Its velocity was higher than the brothers had wanted—twenty-two to twenty-seven miles an hour—but they felt that "it might die down before long."

So, during the early hours of the morning of December 17th, they remained indoors, hugging their improvised stove. A large carbide can was the principal element in its construction. But nine o'clock, then ten, arrived, and the wind was as brisk as ever.

ORV'S TURN

"We can't wait longer!" they determined at last. "Wind or no wind, we better get the machine out and have a try at it."

So up went the signal for the men of the life-saving crew, and out into the biting wind went the Wright brothers, determined that nothing was going to keep them out of the air that day!

"We can face the machine directly into the wind, and there ought to be no trouble in getting it to rise," they reasoned. "It'll be hard to fly it in so strong a breeze as this, particularly since it's a new machine and we haven't had practice in operating it. But, because of the high wind, the flyer's speed with relation to the ground will be low, and the landing velocity will be slow enough to make that part of it extra-safe."

A level spot a hundred feet north of the hangar was chosen as the place to lay the track, and Wil and Orv set to work at the job. Soon four men—Dough and Daniels, who had watched the abortive attempt the preceding Monday, A. D. Etheridge, also of the life-saving crew, and W. C. Brinkley of Manteo—and a boy, Johnny Ward from Nag's Head, were watching and helping. These five were their only observers, although the entire countryside had been informally invited to watch the experiments. The unusually cold

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weather kept most of near-by North Carolina indoors.

It sent Wil, Orv, and their helpers indoors from time to time, too. The wind chilled fingers and blew through coats, and none of them cared to work out of doors long at a time. So the visits to that carbide can stove were frequent.

By 10:30 everything was ready. An anemometer showed wind velocity to be about twenty-seven miles an hour as the machine was faced into the breeze and the wire to hold it in place on the track made fast. Wil looked at Orv.

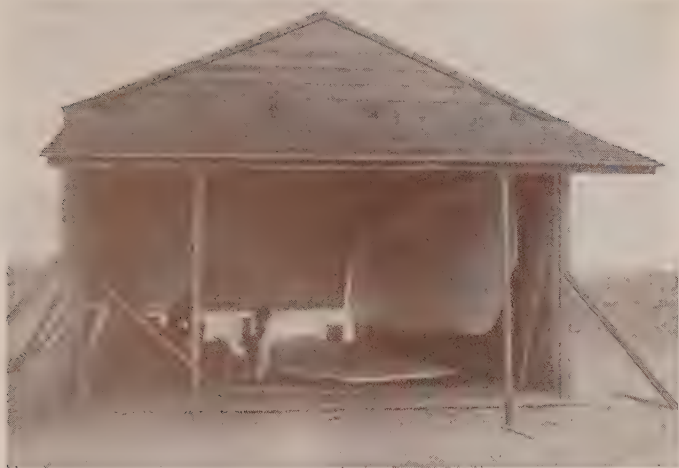
"Your turn!" he said.

And Orv climbed into the machine. The motor was started, and Orv allowed it to run for several minutes to warm it up. Then he called to his brother.

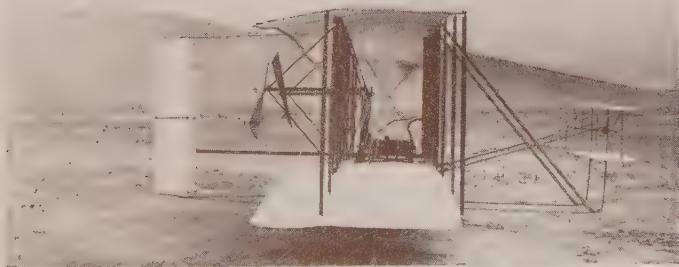
"Everything ready?"

Wil, his eyes gleaming, nodded. Orv turned to peer over the track stretching sixty feet ahead of him, and the rough sandy ground beyond it; he settled himself in place. He released the wire that held the plane back. Slowly, with Wil running along holding the end of the right wing, it started forward.

But not as it had started three days before, on that hill slope. The wind against it was strong



THE FIRST HANGAR AT KITTY HAWK: THE WRIGHTS PUTTING A
GLIDER TOGETHER, ORVILLE IN THE FOREGROUND



THE WORLD'S FIRST POWER PLANE, AT KITTY HAWK

ORV'S TURN

enough so that its first movement was very slow. For forty feet it remained on the track, and Wil was able to stay with it until it actually rose into the air. The first picture ever made of a machine lifted from the level into the air by its own power (one of the life-savers snapped it just at that moment) shows Wilbur running at the end of the wing, with the plane two feet off the ground.

It picked up speed and climbed a little then, and Wil was left behind. Orv found his hands full. He did not know the idiosyncrasies of this particular machine. The air was uncommonly tricky—full of sudden currents and whirls that hampered the machine's flight, and the elevator proved to be faulty. It was balanced so near its center that, once started to turn, it continued the movement of itself, and it kept going from one extreme to the other.

So the course of that first flight was far from smooth. Up and then down again, at lightning speed, the plane seemed to shoot. Ten feet off the ground one second, it would dart to within a few inches the next. And at the fourth downward dart it went too far and struck the sand.

One hundred and twenty feet from its starting-point the excited brothers found that descent

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to have occurred. Twelve seconds the plane was in the air.

Not, on the surface, a startling record. And yet it was the first time a plane had managed to lift itself from the ground and ascend, had sailed forward without reduction of its speed, and had finally landed successfully at a point as high as that from which it had started.

Man had flown! Those four men and a boy had seen the two Dayton bicycle-makers make something else that day. History had been in the wings and propellers and motor of that awkward, hopping flying machine; for it was the precursor of all of the marvelously accurate and successful airplanes the succeeding decades were to bring forth.

Wil and Orv, characteristically, were not unduly excited, now that their dream had become a reality, needing only minor touches to make it a glorious success. Their principles were right; perfect the details and they would finish their job.

They indulged in a little mathematics as they took the machine back to its starting-point. Wil was to have next try at it. The speed of the machine, they found, had been ten feet a second over the ground; the wind speed was thirty-five

ORV'S TURN

feet a second. Thus the machine went through the air at a rate of forty-five feet a second; and if it could have flown at this wind speed in calm air, it would have flown 540 feet in the twelve seconds it remained aloft.

“Some day,” prophesied Wil, as he got ready for his trial, “somebody’s going to make a plane with a motor powerful enough to raise it in still air, and then it’ll make more than that speed—more than thirty miles an hour. Imagine it!”

CHAPTER XXVIII

FURTHER FLIGHTS

ORVILLE WRIGHT, in a magazine article, has told the story of the further experiments on that day, December 17th:

“At 11:20 Wilbur started on the second flight. The course of this flight was much like that of the first, very much up and down. The speed over the ground was somewhat faster than that of the first flight, however, because the wind was lower. The duration was less than a second longer than the first, but the distance covered was about seventy-five feet greater.

“Twenty minutes later the third flight began. This one was steadier than the first one an hour before. I was proceeding along pretty well when a sudden gust from the right lifted the machine up twelve or fifteen feet and turned it up sidewise in an alarming manner. It began sliding off to the left.

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"I warped the wings to try to recover lateral balance and at the same time pointed the machine down to reach the ground as quickly as possible. The lateral control was more effective than I had imagined, and before I reached the ground the right wing was lower than the left and struck first! The time was fifteen seconds, and the distance over the ground a little more than two hundred feet.

"Wilbur started the fourth and last flight just at noon. The first few hundred feet were up and down as before. The course for the next four or five hundred feet had but little undulation. When out eight hundred feet, however, the machine began pitching again, and, in one of its spurts downward, struck the ground. The distance over the ground was found to be eight hundred fifty-two feet, the time of the flight fifty-nine seconds.

"The frame supporting the front rudder was badly broken, but the main part of the machine was not injured at all. We estimated that the machine could be reconditioned in a day or two."

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Then came calamity—calamity told in the matter-of-fact, dispassionate manner that only a Wright could tell it.

“While we were standing about discussing this last flight, a sudden strong gust of wind struck the machine and began to turn it over. Everybody made a rush for it. Wilbur, who was at one end, seized it in front; Mr. Daniels and I, who were behind, tried to stop it from that angle, attempting to hold on to the rear uprights.

“All efforts were vain. The machine rolled over and over. Daniels, who had retained his grip, was carried along with it and was thrown about head over heels inside the machine. Fortunately he was not seriously injured, although he sustained bad bruises from falling about against the motor, the chain, guides, and so forth.

“The ribs in the surfaces of the machine were broken, the motor was injured, and the chain guides badly bent, so that all possibility of further flights with it for that year were at an end.”

Nevertheless, they had flown. And their first

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act, after the accident to the plane, was to take Bishop Wright's dollar and get a telegram off to him, telling of their success.

That was Thursday. Before another week was up the wrecked machine was crated and shipped to Dayton, tools and extra materials with it. Soon afterward Wil and Orv were on their way.

They had plenty to talk about now. For within ten days after Professor Langley's second failure to fly they had proved their theories of flight successful. Now they had to improve on what they had done—to plan for the construction of a new plane, new motor, new propellers.

"Next year ——" they were saying, as the train roared toward Dayton with them. "Next year ——"

CHAPTER XXIX

THE UNINTERESTED WORLD

NEWSPAPERMEN had given little credence to rumors of the experiments of the Wright brothers at Kitty Hawk, if, indeed, many knew anything at all about them. The fact that the first successful flights took place only eight days after the second Langley failure, while journalistic wits were still laughing over the "amphibious aërodrome," was enough to keep most managing editors from treating stories of the Wrights seriously. Before December 17th there had been almost complete ignorance of, and silence about, their work.

There was one reporter, however, who believed that a big story might be hidden away in the sand hills of North Carolina. He was Harry P. Moore, of the Norfolk, Virginia, *Virginian-Pilot*. Moore was a correspondent for the Norfolk paper, and his job took him through several of the small towns in the Manteo-Kitty Hawk district; he heard of the experiments, and made ar-

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rangements to keep in daily touch with what was going on.

On the evening of December 17th, therefore, he was able to send a long story to Kevil Glennan, city editor of the *Virginian-Pilot*. Glennan had known in advance that the story might be coming along, and he knew that Moore was trustworthy. So, the next morning his paper was the only one in the United States to have a complete, detailed account of what had happened.

Glennan, in turn, had connections with several metropolitan newspapers, and he sent eight of them dispatches. So, that morning, December 18th, brief stories on the flights of the day before appeared in the *Washington Post*, the *Cincinnati Enquirer*, the *New York American*, the *Philadelphia Record*, the *Chicago Inter-Ocean* and several others.

That was the extent of the nation's popular notice of the Wright achievement. It is interesting to read what the *Virginian-Pilot* said of the personal appearance of the brothers at this time (interesting because so much of it is wrong!):

“Wilbur is a well-groomed man of prepossessing appearance. He is five feet six inches tall, weighs about one hundred fifty

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pounds, and is of swarthy complexion. His hair is raven-hued and straight, but a pair of piercing deep-blue eyes peer at you over a nose of extreme length and sharpness. His brother Orville, on the other hand, is a blond, with sandy hair and fair complexion, even features and sparkling black eyes. He is not quite so large as Wilbur, but is of magnificent physique."

If the newspapers took comparatively little interest in the new scientific marvel, however, marked curiosity was shown in other quarters. Wil and Orv returned to Dayton planning to build a stronger, more powerful machine for the next year, and tentatively selected the Kitty Hawk camp as the proving-ground for the fifth time. They felt that, in spite of their successful flight, they were far from the end of experimental work.

"It is true," Orville declared not long after the flights, "that in the past few days numerous scientific men connected with the federal government have been here to manifest deep interest in the machine, but as yet we have been tendered no offer of a purchase of our rights. It would be, of course, premature for the government to make



ORVILLE WRIGHT



WILBUR WRIGHT

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such an offer, or for us to entertain such a proposition until we complete our work and go before the world with a perfected practical aërial vehicle.

"I will say that the United States has as yet taken no official cognizance of our invention, although, as I say, several *attachés* of the scientific departments of the government have displayed keen interest."

It was the government of another nation that first took official notice of the work the Wrights were doing. At this time both England and France were working hard at the problem they had so far failed to solve—that of power flight. Their governments, looking at the new invention from the military angle that neither the Wrights nor the United States government had examined carefully, thought of the airplane as a powerful weapon in their own hands, a deadly one in their enemy's.

So, as early as 1904, the British government sent a representative to Dayton to talk to the Wright brothers. The man was Colonel Capper, head of the "Royal Aircraft Factory." The two men welcomed Colonel Capper courteously, and felt a certain elation at the recognition thus given their work. But his advances, his offers to con-

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sider purchase of planes and patents, they consistently met with refusals.

"It wouldn't be square to our own government," they told Colonel Capper, "to sell our work to a foreign nation before the United States has had a chance at it. If it is valuable to you, it must be valuable to America.

"No, we must offer it to Washington first, and we aren't quite ready to do that."

There was more experimenting to do, many improvements to make. Eventually these were far enough along, the brothers felt, that they could afford to ask the men at Washington whether they were interested in the airplanes the Wrights expected to build.

It is probable that a new reason, financial problems, had its part in persuading them, at last, to seek to sell their invention. At first they had gone into the work merely as a sport. Octave Chanute had taken little interest in their experiments, in fact, before he had learned that their aim was entertainment, not personal gain. It was not until they discovered, to their amazement, that they were the world's foremost aëronauts that they set to work to make a power plane. And even then there was no thought of repayment of their investment.

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But the investment had become so large that there was no longer possibility of disregarding it. They had put most of their savings into the gliders and that first plane; they had little left. Moreover, their future expenses promised to be greater than their past, and they had given up their one source of income, the Wright Cycle Company, to devote all their time to the development of their plane.

So some means of increasing their funds had to be found.

Why not sell planes to the government?

But the decision, at length, was that the time was not yet quite ripe to approach the government.

"We believe in our plane," Wilbur argued. "But we can't make it do everything, yet, we want it to do. That side-slipping on a turn, for instance. . . . No, we must wait awhile."

So they decided to wait. They argued and talked—but they waited.

CHAPTER XXX

THE SECOND AIRPLANE

MEANWHILE experiments with a second airplane were progressing. The original plan to return to Kitty Hawk had been given up in favor of remaining at Dayton. Wil and Orv were willing to forego the advantage of continuous wind in order to be nearer their headquarters; they did not want to experience again delays such as the faulty shafts had caused them in 1903.

The first step was to find an experimental grounds. Torrence Huffman, a resident of Dayton, came to the brothers with a solution of this difficulty.

“Why don’t you go out on my land at Huffman Prairie, near Simms Station? It’s just eight miles east of Dayton, and it ought to be about what you want.”

Investigation proved it to be the exact thing—an open area far enough from town, the Wrights thought, to discourage too many curious onlookers from coming to watch. So a shed, similar

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to those still standing near Kill Devil Hill, was erected, and the work of assembling a second plane was commenced.

The 1904 machine differed little from the first. It was heavier and stronger, but it was operated in the same manner as its predecessor. With slightly more power, the inventors expected it to perform more satisfactorily, and presently, when it was ready, they thought it fitting to make its first flight a public ceremony.

Consequently, word was sent to the Dayton newspapers—always a little skeptical about the flying aspirations of these West Side bicycle manufacturers—that a trial was to be held, and reporters and others were asked to be present.

“Just one condition,” Wilbur warned the reporters. “We don’t want you to take any pictures of the machine or the flights, because we don’t want crowds to be attracted to the flying-field. And pictures would interest ten times as many as unillustrated stories.”

On the mild spring day set for that first flight, about fifty persons traveled the eight miles out to Huffman Prairie—fifty persons who were impelled far more by curiosity than by belief in such a paradoxical thing as a machine that flew. It was much the largest assembly the Wrights, as

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aviators, had faced, and its size caused them to break one of their firmest rules.

For the day was so mild that they were convinced the machine would not take the air. The wind was only three or four miles an hour, and with this handicap even this more powerful machine could not lift itself from the ground on the short track constructed for it. Ordinarily Wil and Orv would have allowed their certainty of this fact to decide against an attempt; they weren't in the habit of chancing an experiment when conditions weren't all they desired.

"But look at that crowd!" frowned Orv, as though he were looking at a World Series mob. "Some of them have come from places a lot farther than Dayton. We ought not to disappoint them."

"Whether we try it or not, we'll disappoint them," returned Wil, "so let's try it!"

There arose an added difficulty, now. The motor was not functioning properly. Instead of crackling smoothly it sputtered and missed explosions, with a resultant diminution of the badly needed power. But they had decided to make the attempt.

So the machine was set on the end of the track, and one of the brothers took his place in it. The

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motor was accelerated, the wire was released, and the plane slid slowly along the track.

But the fears of the flyers were too well founded. It never lifted an inch. When it reached the end of the track it merely slid off; its two skids ground into the earth, and it stopped.

Badly disappointed, Wilbur turned to the crowd.

"No flight today. But we'll try it again tomorrow."

It is easy to imagine the half-veiled grins, the facetious remarks that greeted this announcement. Nevertheless, several of the newspapermen returned the following day, still in hope that a story might develop here. Casual spectators were almost entirely missing.

And again things went badly. The motor was still misbehaving, and although it lifted the plane into the air at the end of the track, the hop was no more than a sixty-foot glide. That was enough to wreck the little confidence the newspapermen had had in such a strange contrivance.

"The reporters, in kindness, concealed their lack of belief in our work," wrote Wilbur. "But the two poor performances to which we had treated them convinced them that we weren't worthy very much of their time."

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There was so much truth in this that, later, reports of successful flights made by the two experimenters at Huffman Prairie failed to interest them.

The successful flights commenced almost at once, however. At first, after the motor had been overhauled and put into first-class condition, the machine was able to make hops of only a few seconds. But as the experience of the brothers increased, as they learned how to take advantage of wind and the power generated by the propellers, the hops lengthened. Soon they had reached a duration of several minutes and distances of more than a mile.

The Wrights had at last made a machine that would fly at will.

But the outside world refused to believe in them. Even in Dayton they were often called cranks. Some self-appointed experts explained that the brothers must have found a method of filling their wings with gas to help the machine to rise; in no other manner was it possible to lift dead weight into the air. And others, knowing that balloons could remain in the air for hours at a time and ascend to heights measured in miles instead of feet, had no patience with this ma-

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chine out in the country. They saw no essential difference between it and a big gas-filled bag!

It was not long before Wil and Orv, in their flights, were attempting a new feat—turning their plane in full flight. At first the mere straightaway flight had seemed quite difficult enough. But as the problems of balancing and of landing properly were ironed out, the brothers began to experiment with this next step.

“A machine that always has to land somewhere other than its starting-place isn’t much good,” they told themselves. “To be effective, it must be able to circle easily and come down wherever the pilot desires.”

So they set to learning to circle, and ran into one of the flying problems that troubles every student-pilot—stalling on a turn. The Wrights did not call it that. Wilbur explained the difficulty this way:

“Sometimes, in making a circle, the plane would turn over sidewise despite anything the operator could do, although, under the same conditions in ordinary straight flying, it could have been righted in an instant.”

A major problem, that. It meant a good many crushed wings—both right and left, for the machine was as ready to fall to one side as to the

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other—and a good many hours of repair work. It meant considerable added expense. And it meant many long evenings of puzzling over the newest problem that seemed to defy solution.

Why should a tendency to lose lateral balance—to dip too far to left or right—while the machine was turning be unaffected by wing-warping and quick change of rudder, although this same loss of balance, if the machine were proceeding straight ahead, was quickly corrected by exactly the same method? Why should not the upward warping of the two upper wing-ends and the downward warping of the two lower wing-ends force them, respectively, down and up and thus aid to regain balance?

It was a problem that remained unanswered all through the 1904 experiments. Meanwhile farmers in near-by fields, and passers-by on the two main highways that bordered two sides of their experimental grounds, with hourly electric cars on one of them, became accustomed to the phenomenon of Huffman Prairie—the big white bird that clattered and soared and descended and occasionally turned.

And finally, on September 20th, the machine completed a circle and came to earth exactly beside the track from which it had started. It had

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accomplished another of the feats the Wrights set for it.

But it had not done it willingly. Only the most consummate flying, the most expert handling of controls and motor, had kept it in the air when it was making those turns. That problem of "stalling on a turn" had not yet yielded itself to solution.

Experiments continued—and the bank account of the brothers Wright diminished.

A big temptation came to them one day when they were working over their plane. Two men—Charles R. Flint of New York, a wealthy business man known as the "Father of Trusts" because of his genius for organizing great corporations, and a partner of P. T. Barnum, the great circus man—approached them with a proposition that would yield them several hundred thousand dollars.

"We'll make a kind of traveling show of your plane," said these men. "We'll take it around the country and make exhibition flights, advertising it everywhere. And we'll charge admission to the grounds over which it will fly. It's sure to make a mint of money. There's nothing like it anywhere!"

But from a suggestion like this Wilbur and Orville Wright shrank almost in horror. In the

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first place, their characters were the absolute antithesis of the showman. They never talked of themselves; they were always self-effacing, incurably modest, fearful of anything that focused public attention on them. Going into such an enterprise as a "show tour" would have been unalloyed torture for them.

Moreover, they could not convince themselves that the airplane was a thing to be exploited at the cost of the general public. With a Puritanical conscience they figured that it would be wrong to demand admission fees from the "common people" to see what was, to them, a kind of public venture. The airplane, they were coming to believe, was a vehicle that might turn out to be of surprisingly great value to man. They were by no means of the opinion that they should *give* their work to the nation; they were as firmly opposed to being subsidized as they were to exploiting their invention in what seemed an unfair and unworthy manner.

They believed, in short, that the airplane, when they had brought it to the state of perfection they were confident could be achieved, should be a business conducted in an ordinary business-like manner. They would, eventually, build planes

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and sell them. At one time, it appears, they had entertained the idea of turning their patents over to the government, as a matter of patriotism. But this idea was gone. They would go into the airplane business.

CHAPTER XXXI

FLIGHTS IN 1905

BEFORE they could do much in a business way, however, Wilbur and Orville had to progress farther in practical experiment.

"We haven't yet learned how to keep the machine from trying to slide over on its side on a turn," pondered Orv. "That's got to be solved, that question. An airplane that won't go round a corner without skidding isn't going to do anybody much good."

So trial flights at Simms Station, with growing knots of watchers as the white bird showed that it could circle and land and dip and rise again, went on, whenever weather permitted. The plane used, now, was bigger and stronger than ever—it had forty feet of wing spread, and it weighed 925 pounds with its motor. The frame, of pine and ash in earlier machines, was now of larch—wood both light and strong. A seat was provided for the pilot; he no longer had to lie prone.

The experiments in those days did not lack in

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excitement. That stalling on a turn almost wrecked Orville one early fall day. He was circling around a honey-locust tree, and congratulating himself on the skill with which he was accomplishing the turn, when suddenly the machine commenced to turn up on one wing and slide sideways toward the tree.

Orville did not relish the idea of wrecking the machine in a honey-locust tree. In spite of its seductive name, a honey-locust has long stiff thorns, and lots of them. Orville tilted the front rudders desperately in an attempt to land the machine before it crashed and dumped him onto the thousands of little spines he knew would greet him.

But he had not yet fully learned the secret of managing the turning plane, and he could not descend quite quickly enough. The left wing struck the thorny boughs of the tree twelve feet above the ground, and Orville thought his time had come. But the plane carried through the branches, slicing off a half a dozen of them; and Orville landed safely soon after.

"Nice way to end a six-mile flight!" he grunted to Wilbur in disgust.

For by that time they were making flights of that distance with some regularity. They were

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learning the "feel" of their plane; they were pretty sure as to its reactions, and they usually knew how to make it behave when it attempted to perform badly.

"It's just that one fault that seems to be beyond us," Wilbur puzzled. "Let's see—when the machine is going in a circle, or the arc of one, it tries to turn over sideways, regardless of what we do with wing-warping and vertical rudder. That means that some extra force is working on it, because wing-warping would easily correct that same tilting if the plane were flying straight ahead. What force is it that works when a thing is going in a circle?"

They figured it out. Centrifugal force—the tendency of an object to fly away from the center of the circle in which it is moving, as a rock whirled on the end of a string swings out—must be the answer.

"Let's try tilting the nose of the plane down a bit," suggested Wilbur at length. "Maybe that'll counterbalance the effect of that centrifugal tendency."

That was the answer. Late in September of 1905 the last important problem in the Wrights' question bag was solved—the last problem, at least, that seemed to them fundamental and im-

mediate. Now they would be ready for a lot of things—for longer and more pretentious flights, for business negotiations, for concentration on the difficulty that was becoming more and more pressing, lack of finances.

At last, after fifteen years, Wilbur and Orville decided to use the nest egg of \$5,000 given them by their father. This money had never been touched until this time; now, they felt, they would be justified in falling back on it.

But even that \$5,000 would not last indefinitely. They had to look farther.

“We have a practical plane now,” one brother told the other. “We can offer to sell it to Washington. We know it will fly—it needs only minor improvements. And we have to realize some income from it. I wonder—will the government be interested?”

It was a solemn question; and the Wrights, with characteristic solemnity, took it very seriously. The decision to offer their patents to the War Department was made, and a letter dispatched. Then, while the brothers awaited an answer, their flight experiments continued.

As the flights lengthened (on September 26th the machine covered the astounding distance of eleven miles) public interest increased. More

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and more men and women came to the field on Huffman Prairie to watch the strange contrivance whir and leap and soar.

"Too many people here," Wilbur worried. "We'll have to stop flying if the crowds get much bigger."

The crowds wanted to know all about things. How did it feel to fly? Was it thrilling? or scary? or breath-taking? Could anybody fly a plane? Why didn't the thing tumble the minute it got off the ground? There wasn't anything to hold it up, was there?

Wilbur once undertook to explain.

"An airplane stays up," he declared, "because it hasn't got time to fall.

"You know how a skater can go over thin ice, even ice so thin that, if he were standing still on it, it wouldn't hold him for half a second. He's moving so fast that the strain is on the ice and off it, moved to another part of its surface, before it has time to break.

"That's part of the story of why a plane stays up. It's not all of it—not by a long way. But it'll help you to understand."

Orville, too, took his turn at explanation.

"In order to show the way in which the machine operates," he told friends, "let us fancy our-

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selves ready for the start. The machine is placed upon a single-rail track facing the wind, and is securely fastened with a cable. The engine is put in motion and the propellers in the rear whir. You take your seat at the center of the machine beside the operator. He slips the cable and you shoot forward. An assistant who has been holding the machine in balance on the rail starts forward with you, but before you have gone fifty feet the speed is too great for him, and he lets go.

"Before reaching the end of the track the operator moves the front rudder, and the machine lifts from the track like a kite supported by the pressure of the air underneath. The ground below is at first a perfect blur, but as you rise things become clearer. At a height of one hundred feet you feel hardly any motion at all, except for the wind which strikes your face. If you did not take the precaution to fasten your hat before starting, you have probably lost it by this time.

"The operator moves a lever; the right wing rises and the machine swings about to the left. You make a very short turn, yet you do not feel the sensation of being thrown from your seat, so often experienced in automobile and railway travel. You find yourself facing toward the point from which you started. Objects on the

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ground now seem to be moving at much higher speed, though you perceive no change in the pressure of the wind on your face. You know then that you are traveling with the wind. When you near the starting-point the operator stops the motor while still high in the air.

“The machine coasts down at an oblique angle to the ground, and, after sliding fifty or a hundred feet, comes to rest. Although the machine lands when traveling at a mile a minute, you feel no shock whatever, and cannot, in fact, tell the exact moment at which it first touched the ground. The motor close beside you kept up an almost deafening roar during the whole flight, yet in your excitement you did not notice it till it stopped!”

CHAPTER XXXII

CONCLUDING EXPERIMENTS

ON THE morning of October 5, 1905, an Ohio farmer was working with a hired hand in a cornfield near the Simms Station flying-field. As he worked a big shadow fitted across the ground and he glanced casually upward.

He turned to his helper with a casual remark: "Well, the boys are at it again!"

He wasn't surprised. He had seen the boys "at it" so often recently that the sight of the great white form roaring and soaring across the sky was no longer a novelty. He had even come to know about how long the Wright airplane usually stayed up; and on this day he noticed a difference, as he was telling afterward.

"I just kept on shockin' corn, and pretty soon I got all the way down to the fence. Well, I want to tell you the durned thing was still goin' round. I thought it'd never stop!"

The flights had been lengthening daily since that eleven-mile record on September 26th. The last major problem in the art of handling a plane

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in ordinary flight had been solved with the discovery that tilting the plane's nose down prevented stalling on a turn. An "ordinary flight" was the only kind of flight that interested the Wrights. Even if they could have imagined that such tricks as the Immelmann turn, looping the loop, flying upside down, and tail spinning would ever become important in a pilot's training, they would have been the last to want to try them. And of course they could not have imagined it. Although they were beginning to envision their invention as an important military weapon, they could not then have believed that acrobatics beyond the power of any hawk would ever find place in its achievements.

So they went about improving their ordinary flight records. On September 30th the machine covered more than twelve miles, being brought to earth—as on September 26th—only by the exhaustion of the fuel supply.

The fame of their accomplishments, at last, began to spread and find credence. Not only Daytonians, but also visitors from more distant points, began to flock to Huffman Prairie. The crowd promised, very soon, to become too large for comfort.

Nevertheless, flights continued, after a much

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larger gasoline tank had replaced the small one. On October 3rd a new record, of more than fifteen miles, was achieved. This attempt was ended by overheating of transmission bearings, to which no oil cups had been fitted. The next day Orville, after liberally greasing the bearings, kept the plane in the air for twenty-one miles; again, however, the lack of proper lubrication brought the machine down.

So that night the brothers and their helpers worked late. Oil cups were fitted to every bearing on the plane, and Wilbur and Orville hoped for a flight of at least an hour the next day.

Their confidence was shown by a smiling remark of Wilbur's to a Dayton friend.

"Orville flew twenty-one miles yesterday," he said. "I am going to beat that today."

That was the day on which the farmer had thought the "durned thing never would stop." And Wilbur almost thought the same thing. For the flight went beautifully and he had made good his boast that he would beat Orville's flight (he had covered twenty-four miles), when the motor sputtered and expired. The plane landed, and Orville came running up with a worried frown.

"What happened?"

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Wilbur stood up to look at the gas tank. He took off the cap, measured its contents.

"It's dry," he replied, ruefully. "We forgot to refill the blamed thing!"

But the plane had remained in the air for thirty-eight minutes, and it had covered more than twenty-four miles at an average speed of thirty-eight miles an hour. It had passed through this flight and the preceding ones without the least damage, and in each had "returned frequently to the starting-point, passing high over the heads of spectators."

Nevertheless, that was the last flight of the year, as far as the public was concerned. The crowd at Simms Station had become so large that the brothers feared for the spectators' safety and the protection of their own rights. They were determined not to divulge any of the secrets of their work or knowledge of their patents until they had completed negotiations with Washington. They always invited observation of their flights, but they objected to too close inspection or to photography of their machine.

So they put the airplane into its shed and announced that experiments for the year were at an end.

Nothing had been heard from Washington, al-

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though more than enough time had elapsed for their letter to be considered and answered. They wrote again.

Eventually an answer came.

"We cannot consider your suggestion that we buy your inventions or that we send a commission to investigate them," it said. "We have neither time nor money to waste on a couple of Ohio cranks. We are not interested."

The attitude of the government clerk who wrote that letter was "markedly similar," declared Charles R. Flint, "to the policy that caused Hotchkiss to go to Paris with his machine gun and, later, the American failure to adopt, adapt, exploit, and control the American submarine inventions of Bushnell, Holland, and Lake."

It was a severe blow, this government setback. It put the future plans of the brothers on an entirely new basis. They had hoped to be able to reestablish themselves financially by selling planes to the government, which they had felt would desire—and should desire—the first opportunity at their offers, now that their plane had proved successful. The government had called them "Ohio cranks." That was the end of that!

Typical of Wilbur and Orville Wright is the fact that, in their formal writings and discussions

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of their work, this sharp repulse never made its appearance. Though they were deeply disappointed, they strictly avoided "telling the world" of the discourtesy to which they had been treated. Instead, they went about finding other markets for their planes. Naturally, since they believed flying-machines to be of greatest value to military departments of governments, they planned to approach European nations with their ideas.

They had, of course, already had encouragement from Europe. There had been the British agent, Colonel Capper. There had been, more recently, a French official; but this man had been sent home with much the answer given Colonel Capper. He had been granted one concession—a photograph of the plane which actually told him little.

But in spite of all this encouragement, they found hard sledding before them. They needed immediate capital, not capital they *might* get after months of negotiations. And for more than a year they did not find it.

"All our experiments have been conducted entirely at our own expense," Orville wrote about this time. "In the beginning we had no thought of recovering what we were expending, which was not great and was limited to what we could

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afford in recreation. Later, when a successful flight had been made with a motor, we gave up the business in which we were engaged, to devote our entire time and capital to the development of a machine for practical purposes. As soon as our condition is such that constant attention to business is not required, we expect to prepare for publication the results of our laboratory experiments, which alone made an early solution of the flying problem possible."

CHAPTER XXXIII

THERE WERE OTHERS

THE one important reason that European nations—France in particular—were taking so much more interest in the Wright plane and in aviation generally than the United States was that France and its neighbors saw flying-machines as incomparable instruments of war. Europe had a background of two thousand years of fighting; it thought in terms of war. The United States, before the World War, was hardly conscious of the aspirations or thoughts of European nations, and paid them little attention except when they threatened to develop new interests in the New World.

France, with potential enemies on every side, wanted this new fighting machine for itself, and it was offering every kind of encouragement to its own aëronauts to develop successful airplanes.

The most successful of the men then working in France along lines vaguely similar to those followed by the Wrights was M. Santos-Dumont, a Brazilian airship pioneer-designer. He had for

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several years been experimenting with flying-machines. The biplane he had chosen as his ideal machine, but he had sought to obtain stabilization by the use of upright vertical veins between the two wings—the old box-kite principle with which almost all of the glider experimenters of the nineteenth century had worked. He was convinced, too, of the usefulness of the dihedral angle machine—the airplane with wings forming a wide V—which the Wrights had discarded before they ever built a glider.

So he took two big box-kites, each some six feet high and nearly three times as long, and each with three vertical divisions—one at each end, one in the middle. These he placed end to end, at the slight angle to conform to the dihedral principle, with enough space for operator and motor between them. A third smaller box-kite he set out ahead as an elevator plane. But he put the elevator farther from his main planes than had the Wrights, and he encased the supporting arms in cloth, something Wilbur and Orville had never done. The propeller was at the rear and there was a three-wheel undercarriage. So his machine looked much like a more modern machine exactly reversed—as though an up-to-date airplane were flying tail first.

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Santos-Dumont made his first successful trial on October 23, 1906, nearly three years after Orville Wright had first flown in his power plane. On that date the Brazilian, working in France, covered about 250 feet in his 600-pound machine. On November 12th he flew again, first 500 feet in five and a half seconds, then 700 feet in twenty-one seconds.

The Voisin brothers, Charles and Gabriel, were working in France along similar lines. They used vertical curtains between wings to act as "automatic stabilizers"; they had landing-wheels and a fifty-horsepower motor—far more powerful than the small home-made motor the Wrights used. A variation in their scheme was the use of a rudder incased in a box-kite tail.

The second Voisin plane, made in 1907 with slight improvements, soon became known as "Farman's plane" because it was operated by Henri Farman, a French bicyclist and motorist who took up the new science. On October 14, 1907, Farman made his first flight in this machine. And this machine showed very markedly the effects of Wright teachings. It had, attached by hinges to the rear of the wings, "ailerons," or controllable flaps which, operated from the driver's seat, acted as did the wing-warping on the

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Wright machines. It had a higher, more distant elevator than the first Voisin machine had had; and in addition to its landing-wheels it was equipped with long "skates" or skids to aid in holding it upright in landing.

Farman was not satisfied with the Voisin plane, and made dozens of improvements and changes. Eventually the machine he flew became actually the Farman plane; in it he established a number of "European records."

In no other country did aviation arouse so much interest or advance so rapidly. S. F. Cody, a leading British experimenter, did not make successful flights at his Aldershot field until 1909. There is no name in Germany, Spain, Italy, or any other country in Europe to take place alongside those of Santos-Dumont, the Voisins, and Farman. France was determined to lead.

And yet the French had to await the directions of the Ohio bicycle-makers, who had developed into the most skilled of scientists, to accomplish their aims. For the Wrights alone, in all the world, had the secret of flight. They only, with their wing-warping that gave them stability when their machine took the air, had found the key. Without that, or an equivalent such as the Voisin-Farman variation—which became a model for

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later development—the automobile would probably remain the fastest means of human transportation.

In America, as the French experimented and the Wrights closed their laboratory to open business negotiations, other experimenters were occasionally being heard of. Not in the newspapers, for the newspapers could not be fooled into printing such nonsense! But in scientific circles, among the few interested in aëronautics, it became known that, in a little shop on upper Broadway in New York City, A. M. Hering, who had been an assistant to Octave Chanute years before during Chanute's gliding experiments, was working on a machine.

And in Hammondsport, New York, Alexander Graham Bell and several assistants were building a biplane—one which, they hoped, would far surpass anything else. One of the assistants was a young man of whom much was to be heard later—Glenn H. Curtiss.

CHAPTER XXXIV

BUSINESS NEGOTIATIONS

IT WAS a lean and discouraging year that the Wright brothers spent after they terminated experiments in 1905. They had been turned down by their own government; nobody but a handful of loyal Daytonians believed in them; newspapermen had come to think it the proper thing to laugh at all such "aërial cranks," and Wilbur and Orville, in turn, had come to shun publicity and reporters with typical Wright consistency.

There were three reasons for this. One was that they feared the premature disclosure of the secrets they had discovered and guarded so jealously. A second was the tendency of newspaper stories, even though they jeered, to draw crowds which hampered their work. And a third was the fact that they were beginning to believe that no newspaperman could quote them faithfully or write authoritatively of their work.

So the two reserved, tight-lipped men—Wilbur thinner of face and higher of forehead than ever,

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Orville also becoming a little bald, but wearing the dark mustache which seemed to broaden and soften his face—devoted their time to attempts to finance their work and to sell it to foreign governments. Only in spare time did they work with machinery, pore over drawings, lay plans for the next machine they would build. And spare hours weren't plentiful—even though, for a full year, they found little encouragement in their search for help.

It was Thanksgiving Day of 1906 when Mr. U. S. Eddy of New York came to Dayton to see them.

"I represent Charles R. Flint," he told them. "Perhaps we can make some kind of business arrangement."

Charles R. Flint was the man who, with a partner of P. T. Barnum, had approached the Wrights once before with the flying-circus suggestion—a suggestion they had felt constrained to reject. But what Eddy now had to tell them was far more promising.

"Mr. Flint would like to talk to you," he said. "Can you go to New York to see him?"

There was, of course, talk and counter-talk; but the upshot of it was that the brothers decided to make a trip East.

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It was early on a biting late-autumn morning when Wilbur and Orville arrived in New York. They wasted no time. At once they found their way to the fashionable address which had been given them and presented themselves at the exclusive apartment of the "Father of Trusts." It was just seven o'clock—hardly the accepted hour for calls of business!

But Flint was neither embarrassed nor irritated. Soon after they had been ushered into his reception room he appeared in a dressing-gown. Then and there they started to explain their work and their hopes to him; and this shrewd financier, judge of men and almost a wizard in his business foresight—he was able to see in the flying-machine, crude as it was, a creation of magnificent possibility, though most men of affairs scorned it—believed and encouraged them.

When they left New York, not many days later, they had obtained the aid they needed.

"You can draw on us up to \$10,000," Flint had told them. "If things go as we hope, that won't by any means be the limit."

From then on the Wright affairs moved more rapidly. The first step was to get in touch with the British government. Perhaps remembering that Colonel Capper of England had been one of

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the first foreign-government emissaries to visit them in Dayton, Wilbur and Orville asked Flint to offer their planes to Capper's country.

Flint at once approached Lord Haldane, the British Minister of War, with an offer to build and sell to the government ten planes, each guaranteed to fly for fifty miles, for \$50,000 a plane—half a million dollars. Lord Haldane replied that fifty miles was too short a distance to interest him. Flint then cabled a second offer—twenty planes, each to fly two hundred miles, for a million dollars!

But Flint's exuberant promises—which outstripped the Wrights' actual performances to that time, although not their confident expectations—seemed too optimistic to the Britisher. "That's Yankee tall talk!" he told a friend. Flint, determined to prove his contentions, offered to exhibit the Wright machine to Ambassador Bryce in Washington, or to pay the costs of a demonstration in England.

And then Lord Haldane and his advisers, eager for a chance at this machine for the past several years, seemed to get cold feet. They "approached so cautiously," said Flint, "that I sent a negative more forceful than elegant." And that was the

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end of Britain's second attempt to get all rights to the machine.

Negotiations were opened with war departments in other countries. But the results were not encouraging; enthusiasm there was none.

"We wondered," Flint wrote in later years, "why we were never taken seriously. Eventually we discovered the reason—that most of the world's war departments were directly or indirectly influenced by German military thought, and the Germans did not openly favor the use of airplanes for military purposes. But they were actually deeply interested; they merely hoped to hold other nations off long enough to give themselves a chance for complete investigation."

In France, at length, a different tack was taken. A group of three men was formed—Hart O. Berg, a Philadelphian; Lazar Weiller of the Astra balloon factory of France; and Léon Bollee, a French motor-car manufacturer. With this group Flint and the Wrights dealt, and the result was that in 1907 the brothers went to France. They did not fly there that year. They talked business. But they practically concluded arrangements for flights in France in 1908—flights that would mean sale of the French patents, in all probability.

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This meant work at home for Wilbur and Orville. To do the work they knew would be asked of a plane, they needed a bigger, stronger machine; and they needed several of them. So they spent the winter and early spring of 1907-08 in their Dayton workshop, producing new planes. These were built with the 1905 machine as a model; but the motor they installed was more powerful, and fuel and water tanks were larger. Not only was the operator provided with a seat, but an additional place for a passenger beside him was built. A new kind of steering-gear was worked out. And the planes were strengthened from wing-tip to wing-tip.

Then came the question of practice—practice that was now vitally necessary.

"It's been close to three years since those last tests out at Simms Station," said one of the brothers, "and that's long enough to forget a lot of things about handling a machine. Besides, we probably won't want to work out so near to Dayton any more now than we did in 1905. Looks as though we'll have to go down to Kitty Hawk again."

So, in April, the old 1905 machine, with new motor, tanks, seating arrangement, and steering

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device, was shipped to the North Carolina coast, and soon after the brothers followed it, straight to the site of the old camp at Kill Devil Hill.

They had, now, definite goals. France, in January, had granted the patents asked for in November. Moreover, the United States War Department, in December, had become definitely interested. The Department's interest did not take the form of direct negotiation for the purchase of planes, however. Although the Wrights were America's only successful heavier-than-air flyers, those who only hoped to fly claimed a share of the governmental attention.

So the government advertised for bids. A plane that would cover 125 miles, carrying two men, at forty miles an hour—that was the official demand. Wilbur and Orville went into conference over this, figured it out, came to a decision.

"We can build such a plane, and deliver it by next August," they decided. "For the plane we should have \$25,000." That was their bid.

Probably they knew there was another bid—that of Hering, who proposed to deliver a machine under the specifications for \$20,000, and to finish his before the Wright plane was ready. But, if they had the knowledge, it did not hasten

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them. They had their work to do, and they went about it in their own way.

They could not foresee what was to come of their experiments at Kitty Hawk when they finally commenced, early in May.

CHAPTER XXXV

SPIES!

WHEN, on May 6th, Wilbur and Orville had their plane rebuilt, with the aid of a mechanic-assistant named Furness and the ever-present life-savers, there was an unseen witness to their first flight.

The man was D. Bruce Salley, a newspaperman who held much the same kind of position on the *Norfolk Landmark* as had Harry P. Moore, in 1903, on the *Norfolk Virginian-Pilot*. It was Salley's business to cruise up and down the coast and pick up occasional news items for the Norfolk paper; and, like Moore, he had learned from various sources that two men with a machine they said would fly were getting ready to try it out.

So Salley kept in touch with progress, and on the night of May 6th he sent off two long dispatches—one to the *Landmark*, the second to the *New York Herald*, with which he also had a connection. The next morning the *Herald*, though exceedingly chary of such news—for nobody be-

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lieved that flying-machines could amount to much, so completely had the Dayton flights by the Wrights missed general public notice—took a chance and published the dispatch on its first news page.

Two men, the story declared, had flown in a machine for a distance of a thousand feet over the North Carolina sand dunes; they had gone up as high as sixty feet, had attained a speed of forty miles or more an hour, and had landed safely. It went on at some length to describe the machine. It was a long box, open on both sides and ends; it had a twenty-horsepower motor, two propellers, and so on.

The story was like a minor tornado in the journalistic world. There was a general tendency to believe it unreliable; but if it were true, newspapermen knew that there was a world-beating story down there among the sand dunes. And so, before the *Herald's* story was many hours old, a little group of journalists was on its way to Kill Devil Hill. These included Byron Newton of the *Herald*; William E. Hoster of the *New York American*; a representative of the *London Daily Mail*, a paper belonging to one of the leading believers in aviation, Lord Northcliffe;

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Arthur Ruhl of *Collier's Weekly*; and James E. Hare, a *Collier's* photographer.

The first move of these men, when they at length came to Kitty Hawk, was to descend on Salley and demand confirmation of his story. He knew it was true, he answered; he had seen it with his own eyes.

"Let's go and see the Wrights about it," suggested some one, then. But Salley hastily demurred.

"They won't see anybody," he explained. "If they knew they were being watched, they wouldn't take their machine out. We've got to keep ourselves hidden."

So the newspapermen set up a secret little camp in the swamp a mile from the one-room shack in which the brothers lived, and settled to watch. For two days, with field-glasses and much impatience, they kept tab on the distant movements of the inventors. Occasionally the propellers flashed, but nothing happened. The reporters were debating among themselves whether it would be best to write their papers that these men were fakers, or to go direct to the Wrights and demand satisfaction. And then, on the third day, "something happened," as Newton of the *Herald* puts it:

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“At other times when the propellers were in motion they had given forth a sound quite like the clacking of a grain reaper, but now we heard that sound increasing with sharper staccato, and as we looked we saw the machine glide swiftly along the monorail and across the white sand, saw men racing along by its side, heard their shouts, and then we saw the machine rise majestically into the air, its white wings flashing and glistening in the morning sun. On it sped at an altitude of about fifty feet. I have never experienced another moment with like sensation.”

Another correspondent writes:

“A hundred yards away the great bird swung to the right and swept grandly by, broadside on. Some cows grazing on the beach grass threw their heads upward and, whirling about, galloped away in terror ahead of the approaching machine. It swept on far above them, indifferently, approached the sand hills three-quarters of a mile to the left, rose, and soared over them and down the other side.

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"Then it was a race back to Manteo to get the big story out to the world, and that was difficult. . . . Another problem was to determine how to write the story. We knew that the flying-machine had made the speed of a fast railroad train, but in those days no one would believe that. We had seen it soar over the tops of the sand mountains and turn corners as gracefully as a sailing yacht, but no one would believe that, either. . . . So we toned down the story somewhat, and even at that we were accused of flagrant faking."

But not for long. For the world seemed at last prepared to believe in aviation. Newspapers not only in New York but throughout the country "ate up" the story; and in a week from the time of that first dispatch Wilbur and Orville Wright were catapulted from obscurity into lime-light that swept the world and made them heroes.

And the amusing thing is that they hardly knew of it. The two quiet men, not yet ready to exhibit their wares in public, were resolved to learn more about flying in their Kill Devil camp; and they welcomed no visitors from the outside. So they paid no attention to the newspapermen—

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though they knew what an imposing array of them had gathered—and went steadily about their work.

It is interesting to see how, in the yellow files of newspapers of May, 1908, the doings of the Wrights became of major importance—how newspapers and the world came to a quickened belief in flight. And it is interesting, too, to note that the world was inclined to think those 1908 flights the first of consequence the Wrights had made.

On May 9th, two days after Salley's first story, a second appeared in the *Herald*. It observed that more flights had been made on May 8th; that the brothers alternated in piloting the machine, although it usually carried the two of them, or one of them and Furness; that only the limit of fuel seemed to limit the length of its flights. And it went on:

“It is the firm belief of the inventors that they have a machine far more practicable than any other heavier-than-air machine ever made, and they expect to break all records. The engine is the lightest per horsepower ever made. It can develop thirty horsepower and it weighs 150 pounds.

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“There can no longer be any doubt about the ability of the machine to fly, and to fly well. . . . The Wrights positively refuse to talk; the only visitors allowed at their camp are Captain Ward and the other life-savers.”

For two days the *Herald* was silent—the two days during which the reporters became so impatient. Then came a new and much longer story:

“On May 11th the Wright plane made the amazing record of 2 7/16 miles at a speed of 46.774 miles an hour!” it said in part. It also reported that “after the machine lights it has to be rolled back to the rail before it can be started again. To do this it is placed on a pair of wheels, and with its engine in action it almost forces itself along.

“Wright brothers guard their machine with utmost care. They will not operate in sight of a stranger if they know it.”

The next day this topic was enlarged: “The Wrights close their doors to newspapermen. If reporters approach while they are working on their machine, they put it in its shed and shut up shop. They will grant full publicity later, they

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say—perhaps in ten days or two weeks, after their present experiments are finished.”

But the Wrights had much to do, the reporters learned, before they expected to be finished. The new steering device was not working satisfactorily, and no extensive flights were planned until both brothers were entirely familiar with it.

The May 14th *Herald* was ecstatic over a three-mile flight the machine had made. “This beats the two-mile record made March 21st in Rome by Henri Farman, for which he was awarded a prize of \$10,000; it also outdistances the performances of Delagrange,” the paper exulted. And it was entirely ignorant that flights of more than twenty miles had been made three years earlier by the Wrights.

A gigantic photograph of the Wright plane, in flight, with the sand hills of North Carolina carefully drawn beneath it, accompanied this day's story. “There is no longer any chance of questioning the Wrights' leadership,” it declared. “Their flight was seen by two separate groups, hidden at different spots. It is the first time that disinterested outsiders have seen them doing what they have told others they could do!”

CHAPTER XXXVI

TO FRANCE AGAIN

IN EIGHT days the Wright brothers had become the heroes of a nation and the darlings of the nation's managing editors. So there was a note almost tragic in the stories that appeared in papers everywhere on May 15th.

“After a history-making eight-mile flight on May 14th, with Wilbur Wright at the machine's controls, the plane suddenly plunged thirty feet to the ground and was destroyed. Wilbur, uninjured, was almost crazed with grief and disappointment.”

This last statement, however, seems to have been more the newspapermen's idea of how Wilbur should have felt than what he actually did feel. At first the reporters considered this accident the end of the Wright experiments. Their machine was smashed. What was there to do until the distant date when another should be built?

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But in a day or so they had more optimistic reports. One was that "the accident was not entirely unexpected; the steering-gear was known to be faulty." And Wilbur declared that the interruption of the flight, which he had hoped to make an endurance test of more than an hour, had been the result of his "pulling a lever the wrong way. It was something that had occurred several times before, but never so close to the ground that the error could not be corrected in time."

The best news, however, was that the brothers had "new and stronger flying machines" in readiness at their Dayton workshops. This was the first public realization that the machine they had been using was actually out-of-date and employed in these experiments solely because of fear of some such accident as had occurred.

Excitement over and interest in what the Wrights were about to do became keener and keener. There was a rumor that one of the brothers intended to go to Europe "to try again" to sell their machines to a European government. But the Wrights were characteristically taciturn; they made no answer to this or to a thousand other questions.

Meanwhile the publicity showered on the

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Wrights suddenly brought forth other important news. Somebody discovered A. M. Hering's workshop on upper Broadway, and reporters found Hering only too willing to talk of the machine he was building.

"I've had my own ideas about automatic stability for more than ten years," he declared. "In the machine I am building I will use the gust of wind that disturbs its balance to right it. My machine will be collapsible; it will have a powerful motor, so that my plane can make a quick getaway, with a weight of only one pound per horsepower.

"I first applied for patents on my inventions in 1898, but was turned down because I based them on a small model machine instead of a large one. Nevertheless, I believe my ideas preceded the development of the Wrights' machine, and that my machine will far surpass theirs. I can build a plane that will carry eight men five hundred miles!"

If Hering had been able to do that he would have taken the laurels directly from the Wrights' brows. But his machine was still unfinished; and while he was still talking and working other men had built and flown an airplane.

These were F. W. Baldwin, Glenn Curtiss,

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Lieutenant T. E. Selfridge of the Army Signal Corps, and others, working at a Hammondsport, New York, laboratory with the scientist Alexander Graham Bell, inventor of the telephone. Bell's plane, christened the *White Wing*, made a flight of 275 feet on May 19th. The flight ended in a slight accident, but on succeeding days further flights were made. On May 23rd, however, the machine fell and was too badly damaged for repair.

Greater excitement was caused by the cable which had come from Henri Farman in Europe. "I challenge the Wright brothers to competitive flight for a prize of \$5,000," exploded the leading European aviator. "I can keep my machine in the air for twenty-four minutes at a speed of fifty miles an hour!"

Even this drew no response from the silent Wrights. On May 20th Wilbur arrived in New York, and maintained a consistent reticence in reply to the bombardment of newspaper questions fired at him. It was known that he was having conferences with Charles R. Flint; but when he was asked his purpose in visiting New York he replied one word:

"Business."

So, although reporters watched his hotel as-

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siduously and hounded his steps, they learned nothing more from him. From Dayton there came a long interview, however—Orville had returned to his home with the salvaged 1905 plane, and had broken his long silence. Some of his views showed astounding foresight; others indicated that even the Wrights had not plumbed the depths of the airplane's possibilities:

"We know that we have made a practical airplane machine, but we are not over-sanguine about its revolutionizing transportation of the future. It will scarcely displace the railroad or the steamboat. . . . The airship, so far as we can see at present, will have its chief value for warfare and for reaching inaccessible places—for such uses as expeditions into the Klondike or to Peking during the siege a few years ago, for instance.

"The value of an airship moving faster than a railroad train for reconnoitering or dropping explosives in time of war is now obvious to the entire world. The airplane will also be of great value in the near future in carrying mail. When properly developed, it will be quicker than any other means for direct travel between two points, except against hurricanes.

"The eventual speed of the airplane will be easily sixty miles an hour. It may even be forced

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up to a hundred. Our last machine made forty, and the one we are now building will be considerably faster. . . . It is clear that there is a certain speed beyond which air resistance makes it impossible to go. Every year gas engines are being made lighter, a fact which will increase the machine's surplus carrying power available for fuel and operator and heavier construction; but at present sixty miles an hour is about the limit.

"The airplane of this speed will have surplus lifting power enough to carry fuel for a long journey. We can and possibly soon will make a one-man machine carrying enough gasoline to go a thousand miles at forty miles an hour. Moreover, any machine made to move at speeds up to sixty miles an hour can be operated economically, at little more than a cent a mile for gas."

On May 29th the *New York Herald*, with a magnificent flourish, covered most of its first page and all of its second with photographs, diagrams, and technical explanations of the Wright planes. A cartoon showed Uncle Sam soaring with wings—one labeled "Wilbur Wright," the other "Orville Wright"—over the countryside. And in a near-by column it carried the news that Wilbur had arrived in France, where he expected to continue experimental flights.

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Wilbur, too, become momentarily loquacious. He told in unaccustomed detail of the hopes of the Wrights, of their accomplishments, of his belief in aviation. He announced that all materials for a plane were on hand, in the care of Hart O. Berg, the American who was associated with Léon Bollee and Lazar Weiller in bringing the Wright plane to France.

And so, while Wilbur was at LeMans, a small French town near Bollee's great motor-car factory, Orville was in America preparing a machine for test flights equally as important. He was to go to Fort Myer, Virginia, across the Potomac from Washington, in August to attempt to pass the tests imposed by the Army Signal Corps.

From England there came to see him Patrick Y. Alexander, representing the British War Ministry. England had seen its mistake in turning down the Wright offers of a year previous; but its interest was aroused too late.

The day of the Wrights had dawned. They were ready to show the world what they had accomplished—to prove that at last man could fly. And the world was on fire to hear of it. The Wrights were, that summer, perhaps the most talked-of pair of men between the poles.

CHAPTER XXXVII

FLIGHTS AT HOME AND ABROAD

THE reason that both the brothers had consented to talk to newspapermen was that the time had arrived, they felt, when publicity for aviation was the *sine qua non*.

As far as they were concerned, most of the experimental work in balancing a well-constructed plane in the air was over. Both Orville and Wilbur, by the summer of 1908, knew a good deal about that. Years before they had said, "When the problem of balance is solved, man will fly." That was done. Such things as improvements and readjustments would go well with what would later have been termed "selling aviation"—showing people what a flying-machine, particularly the Wright machine, would do.

So Wilbur was ready to start work at LeMans, and he moved into the shed where the parts of the plane, shipped from America, had been gathered. He had a job on his hands—the job of putting the flying-machine together.

The French were amazed, both at his planning

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to do the work himself and at the extreme simplicity of the quarters he occupied. His bed was a cot shoved out of the way in the daytime, at night pulled out near the machine that was gradually taking form. And as for being his own mechanic ——

“Orv and I always put our machines together ourselves,” he explained. “No reason for stopping now—particularly when nobody here knows as much about it as I do.”

On August 8th he made the first flight, and he became at once a hero to the volatile French. For his machine, it seemed, lived up to his claims for it; more than that, it outdid French machines a dozen ways. Occasionally before that time Wilbur had been called *bluffeur* by doubting French critics—just as Lord Haldane of England had accused the Wrights of bluffing when he said, “That’s Yankee tall talk!” Now the French were forced to believe him. Day by day he bettered the machine’s performances, until it was circling and soaring in September as well as had the 1905 machine at Dayton three years before. On September 6th, at Chalons, he flew for an hour and four minutes with a passenger—the first flight in history of such length with such a load.

During these days Wilbur was often asked why

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he did not employ wheels on his machine to enable it to take off without a special track, and to land more easily. He had his answer ready:

“First, we would require a much more powerful engine—and that means a heavier one, for an airplane engine’s weight depends on its power—to enable us to use wheels. It takes more power to get a machine started from a standstill than it does to keep it going. Second, the use of skids on which to land serves as an excellent brake on landing speed. Skids can be built strong enough to stand the shock of landing, moreover, more easily than can wheels.”

In order to reduce the engine power needed for starting a plane, Wilbur had developed a kind of catapult to set it in motion. This consisted of the monorail track, with a pylon at one end. At the top of the pylon was a pulley; “a line led over this pulley, from a heavy weight on the ground, down to the end of the rail, along the rail to the outer end, over another pulley and back along the rail to a little carriage on which the machine was mounted.

“When the line was pulled back to the carriage the weight was hauled to the top of the pylon. On releasing the carriage the weight fell down, hauled the carriage, and with it the airplane, for-



THE KING OF SPAIN BESIDE WILBUR IN A WRIGHT PLANE—ON THE GROUND!



PLANE, PYLON, TRACK AND CROWD AT LEMANS, FRANCE

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ward along the rail, and gave the necessary speed to enable it to rise into the air. The carriage was, of course, left behind."

This device accomplished the end Wilbur and Orville intended—it made possible the use of a less powerful and lighter motor than would have otherwise been necessary. But the catapult and the skids proved to be a decided disadvantage not long after those early flights, when it was competing with machines of wheeled landing gear and more powerful motor. And it made imperative the use of some kind of small truck to take the machine, after it had landed, back to its starting device. So within a year or two the skids and catapult were to be discarded.

In America, while Wilbur was thrilling France, his "kid brother" was proceeding to electrify the United States. For Orville had taken one of the machines built at Dayton during the preceding winter to Fort Myer, and was making flights preparatory to attempting to pass the governmental tests.

His progress was as startling as Wilbur's. On September 9th he made two remarkable flights with a passenger—one of fifty-seven minutes and another of more than an hour. Great crowds gathered; Senators and bootblacks, business

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giants and fruit peddlers alike journeyed across the Potomac to watch him. And on September 17th, the greatest tragedy in the history of the Wrights' flights occurred.

Orville had ascended in his plane with Lieutenant T. E. Selfridge, the young Army Signal Corps man who had participated earlier in the trials of the Bell *White Wing* at Hammondsport; Selfridge had actually flown the machine for a thousand feet, its longest hop. The Wright machine was soaring as usual; the admiring throng below was noisily enthusiastic. And then, suddenly, the big white kite faltered; it lost momentum, stalled—plunged with increasing, sickening speed to the ground.

When the horror-stricken soldiers and mechanics reached the crushed, shattered remnants of the airplane, they found that Lieutenant Selfridge had died instantly—the first man in the world to meet death in a power flying-machine accident. Orville was terribly injured; and while attendants were carrying him off the field on a stretcher the spectators stood in ghastly silence, fearful of word the physicians might send back.

But before long news came. "He will live. He is dangerously injured; his back is badly wrenched. But he will recover."

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And soon afterward somebody asked Orville whether he believed the accident would kill his "flying nerve." His answer was typical of the man:

"The only thing that worries me is that I may not get well in time to finish the government tests this year!"

His fear was justified, for he made no more test flights that fall. But Wilbur, over in France, just a week after the accident at Fort Myer, was continuing his record-breaking performances. On September 24th he covered twenty-five miles in fifty-six minutes. On December 18th he flew for two hours—the longest flight in history. On that same day he climbed in his machine to a height of three hundred feet—another record, and a last convincing answer to that French *bluf-few* taunt.

The result of all these flights was that at last the Wrights and their backer, Charles R. Flint, commenced to recover some of the money they had invested. For the *Compagnie Generale de Navigation Aérienne* (General Company of Aërial Navigation) was formed in France, and the price paid for the French right to the Wright patents was \$100,000.

That news must have meant to the Wrights

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what the fall of Troy meant to Menelaus. The actual sum, \$100,000, would today seem small for an invention of such transcendent importance. But it was more than a hundred thousand dollars to Wilbur and Orville. It was recognition of their leadership, admission that they had done what they set out to do.

It was acknowledgment that, in the face of doubt and ridicule, they had taught man to fly.

And Wilbur ended the year—the most notable year, perhaps, in the history of aviation, for it was the year that showed the world its newly sprouted wings—in new glory. On December 31st the French Michelin company, tire manufacturers, held an international aviation contest at Auvours, for the Michelin Trophy. With a flight of ninety miles, made in two hours, twenty minutes, and twenty-three seconds, Wilbur won this trophy. To do it he had to defeat nearly every aviator and aëronautic inventor of importance in Europe.

CHAPTER XXXVIII

GREATER GLORY

WHILE Orville was recovering his strength Wilbur followed his December 31st triumph with other achievements. In the spring of 1909 his headquarters were moved to Pau, a little town in the shadow of the Pyrenees in southern France; there he established the first aviation school in the world. And there came pilots of importance from everywhere in Europe to study and observe.

There came, too, royalty. King Alfonso of Spain, an ardent sportsman, was an interested visitor. He even went so far as to sit in the operator's seat and handle the controls. Wilbur, not at all awed by Alfonso's august presence, invited the king to take a ride with him. But Alfonso, apparently, did not trust the slight-looking machine to carry so regal a responsibility. He thanked Wilbur effusively.

"But before I came to the flying-field," he concluded, "I promised the Queen I would not ascend. So I cannot accept your invitation!"

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Flights were made, too, before King Victor Emmanuel of Italy. Italy could not afford to be behind France in aviation; and in 1909 the Wrights sold Italian rights to their patents for \$200,000. It was about this time, too, that a group of six English sportsmen agreed to pay \$25,000 each for six planes. They drew lots to decide which should get the first machine, and the winner, Charles S. Rolls, later a world-famous automobile manufacturer, became the world's first private buyer of an airplane. Robert J. Collier, whose interest in aviation had induced him to follow the work of the Wrights closely in his *Collier's Weekly* since their "discovery" the year before, was the first private citizen in America to buy an airplane.

Several months before Wilbur came home that spring Orville and the sister who had been so firm a believer and so staunch an ally had gone to Europe to join him. Orville's strength was normal by that time; he took over some of the burden of exhibiting Wright machines to Europe. He flew before King Edward VII in England, taking Katharine as passenger—much to the astonishment of Edward! And, together with their friend Flint and his wife, they went to Berlin.

The German government had been officially

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cool toward Wright planes. But the time was past for anything but acknowledgment of the superiority of the Wright machine and the necessity for its general adoption or adaption. When Orville made exhibition flights in Berlin, therefore, such notables as General von Moltke were in attendance. Newspapers reported the remark of Kaiser Wilhelm II as he shook Orville's hand: "You have revolutionized modern warfare."

The Kaiser took prompt action following the exhibitions. At a meeting to which he called twenty important German industrial figures, many of them already deeply interested in the construction of lighter-than-air machines, Wilhelm spoke briefly on the need for German purchase of the Wright patents. "I leave this matter to you, gentlemen," he concluded. Then he left the room.

His "command" was obeyed. The *Flugmaschine Wright Gesellschaft* was formed, and Germany fell into line with the other nations.

The return of the Wrights to America was a miniature of the overwhelming ovations given to Charles A. Lindbergh, who first flew from New York to Paris, eighteen years later—a miniature because New York had not yet learned the technique of welcoming returning heroes. For 1909,

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it was a notable occasion. As their liner steamed up New York Harbor whistles broke into wails and screams and shrieks; flags waved, people cheered. Two quiet men who preferred the peace of their laboratory to the plaudits of the crowd were greeted with such a panic of noise as New York had rarely known.

By this time honors were beginning to be heaped on the Wright shoulders in quantities more overwhelming than New York's greeting. Colleges and universities in Europe and America conferred honorary degrees on them. They were banqueted and *fêted* wherever they went; Dayton, where the newspapers had scorned their early attempts at flight, was more than eager to acclaim its most noted sons. The brothers received it all good-naturedly if not with wild enthusiasm. At a dinner in Paris Wilbur had been asked to speak, to tell of what he had done; and his response had been characteristically terse. The next talker remarked that "among birds the parrot is the best talker—and the worst flyer!"

But they had only spare hours for such occasions. When, on June 10, 1909, President Taft presented to them medals from the Aëro Club of America, he said, "Many great discoveries have been accidents. But you Wrights have had no

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accidental discoveries—you have merely done what you set out to do.”

They still had tasks to do, and they set out at once to do them. The first was to finish the tests at Fort Myer, commenced almost a year before. The governmental requirements had been somewhat modified; an agreement had been made that \$25,000 would be paid for a machine that could carry two men ten miles at a speed of forty miles an hour. For greater speed, the price was to be augmented \$2,500 a mile: if the plane went slower, however, it was to be cut at the same rate. The minimum speed acceptable to the government was thirty-six miles an hour.

There had been some speculation, since Orville's accident, as to whether he had “lost his nerve.” To Orville the coming flight at Fort Myer was more than a vindication of his nerve; it was a vindication of aviation. He wanted the world to know that the failure in 1908 meant little—that he could do what he wanted to do with his plane, and do it at the same place where he had fallen before. He insisted that tests be held over precisely the same ground.

And his preliminary flights alone bore out his confidence in his machine and his ability to handle it. On one of his flights, with Lieut. Frank P.

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Lahm as a passenger, he remained in the air for one hour and twelve minutes, breaking Wilbur's world's-record for flight with a passenger. He made longer flights by himself. And at length came the day for the official trial.

The test course was a five-mile stretch from Fort Myer to Alexandria, Virginia—ten miles over trees, railroads, and rough and unbroken country which would make flying extremely difficult. "Such a flight," it was declared, "involving the crossing of air currents thrown up by hills and gullies, and the possibility of landing among trees, is a far more hazardous exploit than crossing the English Channel."

There was a tremendous crowd. The President was there; the astounding array of automobiles back of his inclosure numbered no less than five hundred cars! Trolley cars, wagons, drays, bicycles and baby carriages—every kind of conveyance—brought the multitude. Congressmen and representatives of every branch of the government were there.

"Orville Wright calmly adjusted his goggles, which are fitted with shades to protect his eyes from the sun," says an account of that day's flight. "He changed his coat, put on a cap which he pulled down over his eyes, and took his seat

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in the plane. Lieut. Benjamin D. Foulois, who was to become a high-ranking air service officer twenty years later, took his place as passenger.

"When everything was ready, the machine was released. It shot forward on its rail, and rose steadily and slowly, circling the field twice to get up speed and to attain sufficient elevation. They turned sharply by the starting tower and passed between the flags which marked the starting line. Amid the cheering of the spectators and the tooting of automobile horns, the machine sped away toward the two captive balloons which marked the course and gave some idea of the proper altitude to maintain.

"It grew smaller and smaller in the distance, and it could be seen that the wind was carrying it slightly out of its course toward the east; but it turned and made for the balloon marking the turning-point, where representatives of the United States Army Signal Corps were stationed. The official time of the turn was taken, and the machine started back.

"There was a moment of suspense when it disappeared from view. The strong downward currents of wind bore it lower and lower until it was hidden by the trees. Soon it came into sight again, however, and rapidly became more distinct

until it swept over the finish line, almost over the heads of the cheering crowds. With a graceful circle it landed near the airplane shed. The time was fourteen minutes forty-two seconds, which meant a speed of a little more than forty-two miles an hour."

Two miles an hour faster than Wilbur and Orville had promised—that was \$5,000 extra! The War Department paid the brothers \$30,000 for a machine, and the struggle that had commenced years before to interest the government in aviation was at last successful.

CHAPTER XXXIX

AND GREATER

THROUGH the summer and early fall of 1909 Wilbur and Orville made public flights, and the public continued to come in droves to watch them perform. Most of their exhibitions that year were at Fort Myer. It was here that they were the continual prey of newspapermen. The nation wanted to know about the Wrights, and city editors sent reporters day after day, week after week, for interviews and photographs.

Wilbur and Orville were not at all seclusive. They were more than willing to have the world watch them at their work, and they were always ready to talk to visitors. But to be photographed or interviewed—that was something else!

“I have never been correctly quoted,” Orville complained once. “Why should I tell newspapermen things if they make wrong statements out of what I say?”

But Orville was meticulously accurate; when he spoke to a reporter of a guy, he meant guy. If the reporter made it “brace” in his story, that

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was one hundred per cent wrong to Orville, even though, in the public mind, the two words might carry precisely the same meaning. It was this habit of exactitude, of course, that had brought success to the Wrights. Little wonder, then, that they insisted on accuracy in stories about themselves.

Even though the brothers usually refused to grant interviews, they were on friendly terms with reporters. Once when Wilbur was surrounded by two dozen journalists he laughingly told the men that they had not earned the right to ask questions.

"Pulling the weight to the top of the starting tower is really the newspapermen's job," he declared. "They always did it for me over in France—because they knew I wouldn't let 'em come near if they didn't!"

On another occasion Orville was asked by an eager young reporter who had questioned him the day before, "How did you like my story today?"

"Fine!" grinned Orville. "It was all new to me!"

The reporter was crestfallen. "Well," he explained, "you didn't say anything yesterday, so

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I used quotations from half a dozen previous stories!"

Once Wilbur's aversion to curious photographers came near to causing trouble. A slight accident to the motor had stopped it while the machine was in flight, and, in the dusk, the landing glide had ended in a tree. Wilbur particularly requested that no photographs be taken—he knew that a photograph of a damaged plane would do serious harm to the cause of aviation. As the machine was being wheeled through the curious crowd to its hangar, however, a man raised a camera and snapped the shutter. Furiously angry, Wilbur snatched a small piece of the broken machine and threw it at the camera; he evaded Orville's detaining hand, jumped police ropes holding spectators back, and seized the photographer. When it developed that the man was an official War Department photographer, however, Wilbur was quickly apologetic. "How can I help you get what you want?" he asked.

In spite of the fact that the Wrights tried to avoid publicity, however, the crowds grew. One man came fifteen hundred miles just to see a flight of the Wright machine; it happened that none was made during his stay at Fort Myer, and he returned to his Middle West home with

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five minutes' conversation with the brothers as his consolation. One day Congress came in a body to see a flight—a windy, raw day. Officials of the War Department, eager to convince Congress that the airplane was a reality, had promoted the occasion; a successful flight, they hoped, might mean a million-dollar appropriation. But they were flabbergasted when the Wrights declared:

"It's too windy to risk a flight today, with the new plane. We won't go up!"

As one of the officials ruefully replied, "It takes more nerve to stay on the ground in front of this congressional crowd, all set to see a flight, than it would to fly in a gale!"

On September 29th Wilbur "startled the nation" by flying around the Statue of Liberty in New York Harbor; and six days later he won the greatest ovation the Wrights had ever received when he flew from Governors Island up the Hudson to the farther end of Manhattan Island, high above the decks and basket masts of the Atlantic fleet, circled, and went back before the eyes of tremendous crowds gathered to celebrate the memory of two other pioneers—Robert Fulton, inventor of the steamboat, and Hendrik Hudson, whose *Half Moon* had sailed there three



WILBUR AND HIS CANOE-HYDROPLANE, READY TO FLY UP THE HUDSON, 1909



IN FLIGHT A FEW MINUTES LATER, JUST ABOVE THE SAND FLATS

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hundred years before. It was on this flight that Wilbur showed to the world the first "hydro-plane." He had a canoe lashed to the skids of his machine, to keep it and him afloat in case of a landing forcing him down onto the Hudson!

Other men were making notable flights now. Bleriot, a Frenchman, had flown across the English Channel in a monoplane—a machine with the Wrights' warped wings, but with stream-lining and motor in front, a forerunner of modern monoplanes. Glenn Curtiss, equipping his bi-plane with one high-speed propeller and movable ailerons, won the Gordon Bennett prize at an international competition at Rheims, France, with a flight of twelve miles in fifteen minutes.

For a number of reasons Wilbur and Orville gradually gave up their active flight. One was the formation of the Wright Company in America, with Wilbur as president and Orville vice-president. Another was that they were already laying plans to train other men to do their flying for them; they preferred to devote their time to the development of their business and, as soon as possible, to further research in aëronautics and aërodynamics.

So, not long after those flights in New York, the Wright brothers were back in Dayton to get

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their factory into operation. There was no lack of interest, or of faith, now. And there was no lack of capital. For now the Wrights had not only money of their own; they had offers of financial assistance from plenty of outside sources.

Before long the brothers had not only completed their business organization, but had also made plans for a new plane. This machine was to have a wheeled undercarriage, a motor powerful enough to start it into motion, and a horizontal tail fitted at right angles to the rudder. A year later, incidentally, they eliminated the front elevator planes altogether; thereafter their plane was controlled by wing-warping and tail only. The change in the position of elevator plane was the only important modification the Wrights made in their plane in all the years that followed that first flight on December 17, 1903.

In 1910 and 1911 the brothers had a number of young men in their employ who learned to fly their planes—students of the first aviation school in America. Among these were such well-known pilots as Ralph Johnstone, Walter Brookins, and Arch Hoxsey; and into the minds of these men Wilbur and Orville did their best to instil their principles of caution and precision, their love of simplicity. A writer in *Scribner's* in December,

1911, told of two concrete examples of the Wright gift of "reducing scientific abstraction to practical working devices":

"In 1910 many people wondered at the strip of cloth about a foot long and half an inch wide hanging from the front rudder of their plane. It was nothing but a signal to give them the important knowledge as to whether the machine was rising or falling, going straight or sliding sideways through the air. There were all kinds of scientific instruments, aërometers and barographs, but there has still to be invented so practical a way of indicating the direction of progress through the air as the fluttering rag of the Wright brothers.

"Another home-made Wright instrument was given a public exhibition at another meet in 1910. Johnstone was up in the air in a Wright machine, mounting higher and higher. The two Wrights were standing together in the middle of the field, watching him through a queer instrument. Suddenly close observers saw the strange spectacle of the Wright brothers smiling, jumping, and peering through their instrument excitedly.

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They said nothing to anyone else; they alone among the thousands around knew that Johnstone had beaten the altitude record.

"The instrument which told them so was a yard stick on which a ring could be slid up and down. On either side of the yard stick, fastened to the sliding ring, were two pointers. These pointers were drawn away from the eye until the wings of the airplane just filled the space between them. The distance of the pointers up the yard stick showed the Wrights just how high Johnstone was flying."

So honors and the long-evaded publicity continued to pour on them. They became doctors of laws and masters of arts; they were made chevaliers of the Legion of Honor. One amusing "honor" that came to them was a request from scientists of the Smithsonian Institution:

"We want to raise a tablet in honor of S. P. Langley, and we propose to inscribe on it an expression of the Langley law—'the faster a plane moves, the less the power required to sustain it.' What do you think of this idea?"

There was no hesitation in answering this question. The "Langley law" was wrong—exactly

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opposite to fact. This the Wrights knew from experiment and experience. The Smithsonian scientists changed their minds about the tablet's inscription.

By 1911 the brothers were "at the head of one of the largest airplane factories in the world, devoting the larger part of their time to research work in the line of navigation of the air." If their desires could have ruled, they probably would have given all their time to research. But the business had too many growing pains for that. There were too many details of production and manufacture, of patent rights and legal procedure, to be handled. In this year Wilbur had to make another trip to Europe, this time to consult with the German government about the construction of planes for military purposes.

So it went through 1911 and the early part of 1912. Building planes; selling them; arguing with this inventor or that, this government or that, over patent rights; attending aviation meets; conducting classes in flying. It was a busy and a fatiguing period.

About May 1, 1912, Wilbur made a business trip to New York. When he returned, a few days later, he complained of feeling under the weather. Before long he went to bed, ill.

CHAPTER XL

WILBUR'S DEATH

AT FIRST it was a headache, a fever, a general wretchedness, that kept Wilbur in bed.

"Just don't feel top notch," he said. "Nothing to worry about. I've felt lots worse. In a day or so I'll be better."

In a day or so he was worse. Doctors were called—Dr. D. B. Conklin and Dr. Levi Spitler—and they looked grave when they had diagnosed Wilbur's case.

"Typhoid fever," they agreed.

But it didn't seem a vitally serious case. For ten days the illness went along without causing anybody more than casual worry. Wilbur didn't appear to be dangerously ill; he had his sister Katharine and his father, Bishop Wright, now eighty-four years old, constantly with him in the little frame house. He was receiving good care. Of course he'd get well.

But about May 16th the situation became serious. Orville stayed home from the factory—now demanding long hours of his time—more of the

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day. Katharine looked graver when solicitous neighbors, anxious newspapermen, worried Daytonians great and small, asked her about her brother's condition.

"He doesn't seem so well today."

And the doctors' attendance became more regular. The patient was noticeably weaker; he didn't rally to the attacks of the fever as he had at first. The poison in his system was too strong.

"It looks bad," the doctors said. "Almost hopeless."

Reuchlin Wright, the oldest brother, was called from his home in Tonganoxie, Kansas. He established himself at the home of Lorin, second oldest of the brothers, in Dayton. And day by day, almost hour by hour, Wilbur grew weaker.

There were times, during the week before May 26th, when he seemed better, when the iron courage that had completely beaten that earlier illness following the blow of the shinny stick, and the indomitable determination that had marked his work for twenty years, seemed strong enough to win. There were flashes of hope for the family and for the interested nation, for newspapers carried bulletins from edition to edition.

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But on Sunday, May 26th, doctors knew that the fight was hopeless. The force of the disease was too great, that of the defending constitution too weak. They quietly told Orville that the partnership that had endured since the days of the *West Side News* was at last to be broken.

Sunday and Monday, Tuesday and Wednesday, passed. This man of steel nerve still lived, but the life-stream was very weak. Most of the time Wilbur was unconscious.

Wednesday night Reuchlin went to Lorin's home to spend the night. Wilbur had a very high fever that night; but he had had high fever other nights, too. At 2:45 Thursday morning it was noticed that he was suddenly weaker. Reuchlin and Lorin were hurriedly called; Bishop Wright, Katharine, and Orville were there already.

At 3:15 Wilbur died.

From everywhere that news wires reached came telegrams and cables of sorrow and condolence. The secretary of war and other high officials at Washington who had come to know the quiet, secure strength of Wilbur Wright made "statements" to the newspapers. Every newspaper reported the death and recounted the life of

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the man. France, England, Germany—dozens of countries joined in the deference paid to him.

And so the whole world—not just a city, a state, a nation—mourned the loss of a leader. The Dayton bicycle-maker who, with his brother, had given the world its wings; the silent, Puritanical ascetic who had conceived and brought to maturity an instrument of royal adventure; the boy cheated of college who had made himself one of the world's leading scientists—that was the man to whom the world paid tribute.

At once, in a dozen spots, came to life the suggestion that a memorial to the Wright genius should be erected. In England the leading British aviator, Claude Grahame-White, proposed a flying meet at Hendon, in which more than a hundred aviators were to take part (to such lengths had aviation advanced in three years) to raise funds for such a memorial.

And in all of the expressions of regret at Wilbur's premature death—he was only forty-five years old—was recognition that it was a partnership that was broken. Orville's part in Wilbur's work was not forgotten. "Wilbur Wright, who with his brother Orville invented the flying machine"—that was the way the newspapers put it.

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Funeral services—the opportunity for Dayton to offer private homage to the man in whom it took so much pride—were held on Saturday afternoon at the little frame home. After the simple ceremony a somber procession went to Woodland Cemetery. There Wilbur was buried.

CHAPTER XLI

ORVILLE WRIGHT, SCIENTIST

NEITHER Orville Wright nor his brother had ever, by other than necessity, sought public notice; rather they had sedulously avoided it. Only when they felt it to be important to the success of their work had they consented to public exhibition and adulation.

Now, with the Wright Company a going concern, its Dayton factory jammed with great white wings, propellers, motors, and accessories, there was little need for Orville to remain a public figure. Aviation was accepted by 1912. The world believed in it, and there were far more colorful flyers—Lincoln Beachey, Harry N. Atwood (who had proposed a transatlantic flight as early as 1911, and in that year flew from Chicago to New York), Glenn Curtiss, Johnstone, Grahame-White, Hoxsey, scores of others—than the Wrights had ever dreamed of being.

Orville had another important reason for going into comparative seclusion. He had work to do. For Wilbur and he had outlined mentally a

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comprehensive research program. Orville's interest was in this program even more than in the manufacture of planes. He had succeeded to the presidency of the Wright Company; this position he found compatible with a certain amount of laboratory work.

So, although he had become a man not only of world prominence, but also of historical importance—a man whose name, with Wilbur's, was certain to be on the lips of children through later centuries, as were those of Galileo, Benjamin Franklin, Gutenberg, Edison, Prince Henry the Navigator, Morse—he now devoted more and more of his time to experiments in his laboratory. He wanted, first of all, to take the next step in securing complete balance to an airplane in flight—the development of an automatic stabilizer.

“We always figured that a way could be found to make an airplane virtually control itself,” he explained. “That is, to the extent of almost entirely maintaining its own balance. That is what I'm after.”

There were business cares, of course. The British Wright Company was organized in 1913, with Orville as chairman of the board of directors; in this year, too, Wright patent claims, over which there had been more than one squabble,

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were protected by court action in several nations where disputes had arisen. The business of the Dayton factory grew.

Then, in 1914, Orville announced completion of the "automatic stabilizer" on which he had been working. It was a device by which compressed air pressure controlled by a wind vane operated the plane's elevators. If the plane should tilt downward, the air pressed against the vane; it, in turn, released air pressure which worked on the plane's elevator and changed its angle so as to right the machine. For his further contribution to aërial knowledge he was awarded the prized Collier Trophy. But the stabilizer never came into general use. Air authorities pointed out that by this time the airplane built on the Wright principle of inertness was extremely stable, anyway. The truth of this was shown in later years, when machines flew for periods of more than half an hour without the necessity for their operators to touch the controls.

In 1915 Orville came even closer to retirement. He gave up his connection with the Wright Company and sold its patents. The new company was called the Dayton Wright Company. Orville became a consulting engineer, albeit one whose main interest was, of course, in aërial engineering. He

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became, for a time, identified with a new airplane industry—the Wright Martin Company. But this did not last. Orville preferred to be completely his own master.

He was still receiving dozens of honors, invitations to dinners and conferences and conventions, a nation's homage. Whenever a new flying record was made—and they were weekly occurrences—his opinion was asked. When a different type of airplane was developed, he was called on to say whether it would fly. Could a man ever pilot a machine across an ocean? he was asked. How fast could a plane travel? Had he foreseen the use of planes in aërial combat? How many pounds of bombs could a big machine transport?

The trend of the questions became suddenly military, for the world was aflame in Europe, and in 1917 the conflagration reached America. In April the United States declared war; Orville was made a major in the aviation service of the army. And at precisely the time that Congress was deciding on war, Bishop Wright died—April 4, 1917.

That reduced the Wright household to two, Orville and Katharine. If their father's death had come at a time when there had been less excitement in the air, less work to do, it would have

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been even harder to bear. As it was, Orville plunged into war work—aëro-science with special emphasis on death-dealing planes—with characteristic energy. Many of the developments in aviation that came from those hectic war years were traceable to the laboratories at McCook Field, the great army post that grew up at Dayton, with Major Wright as one of its leaders. Some day, perhaps, the full tale of the engines of destruction planned and perfected there will be told. But during the war and for years afterward they remained carefully guarded military secrets.

The war ended. Again Orville became a private citizen, and again he gave himself over to aëro-nautic investigation, to development of aërial instruments, to experiments. He was, for a term, president of the famous Engineers' Club of Dayton, a president who, in his meticulous attention to detail, often made meetings last twice as long as did other less precise officers! He built for himself a special laboratory—still on Dayton's West Side, at 15 North Broadway.

His office and his workshop in the low red brick building on North Broadway became the center of Orville's life. Demands on him never ceased; but he learned to weed out those that

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seemed unimportant or lacking in interest. In the workshop he carried out his experiments. There, too, he reassembled the first power plane he and Wilbur had built—the one that had flown and been wrecked by the wind on December 17, 1903. The Smithsonian Institution wanted that machine, to add to its collection of famous airplanes. But Orville refused to commit his machine to the Institute's keeping. He had two reasons. One was that, in 1914, Institute officials had permitted the Langley aërodrome to be removed, altered and flown. The other was that the inscription on this machine, Orville felt, gave credit for developing the first man-carrying power plane to Langley instead of to his brother and him. So, in 1928, he shipped his plane to the South Kensington, England, museum—and the world's first airplane, America's development, left home soil.

At his shop Orville received his friends, often. One whom he saw there was Edward H. Sines—the same "Jammies" who had been playmate and partner forty years before.

Orville's skill in mechanics, and his complete absorption in aëronautics, were again exhibited to Sines in two of those visits, a week apart. On the first of these Sines told his old friend of a

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new adding-machine he had just seen—a mechanical marvel, Sines said.

“How many keys has it?” demanded Orville, quickly.

“Well, a lot—nine ones, nine twos, and so on——”

“Too many,” Orville mused. “I could make one— Well, you wait and see.”

Sines was in the shop a week later. “Remember what I was saying about an adding-machine?” Orville asked. “Take a look at this. It shows what I meant.”

And he displayed a rough working model of an adding-machine that did all the work of the many-keyed machine, with only nine keys! Another example, that, of Wright simplification.

But Orville did not want to bother to develop his machine. Adding-machines were not in his line; he was too much occupied with aëronautics.

At LeMans, in France, they had raised a monument to Wilbur’s memory—a white marble shaft, the figure of a boy reaching toward the skies at its peak, and reliefs of Wilbur and Orville, together with the Frenchman who had been instrumental in bringing Wright planes to France, Léon Bollee, on the face of the column. It had been

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dedicated on July 17, 1920, with Premier Mille-
rand the principal speaker.

And so, while Lindberghs crossed oceans and airplanes performed ever new and astonishing feats; while mail and passenger routes became safe, regular, and commonplace throughout the world; while flivver planes and giant triplanes, armored planes and pleasure planes, seaplanes and planes of lightning speed made known strange peoples and visited perilous places; while business came to rely on aviation as an everyday necessity and the advance of the flying-machine became an everyday phenomenon ——

There worked in that Dayton laboratory, or in the secluded, off-the-trail camp in Canada he had acquired, a mild-mannered, blue-eyed man, a man who sought still greater advance in the science of flying; a man to whom monuments, after all, meant little, accomplishment much; a man who probably knew more about the laws of flight than any other who ever lived; the man who first made a crazy-looking mass of muslin, wire, sticks, and machinery leap into the air and fly:

Orville Wright.

His name and that of his brother Wilbur are among the great. As nobody knew better than the Wrights, the possibilities of the airplane are

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veiled behind a screen that hides development beyond imagination. But when the screen is moved aside, when the last account of the development of mechanical flight by man is written, two names will head the list:

Wilbur and Orville Wright.

THE END

